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STUDY OF V/STOL AIRCRAFT IMPLEMENTATION

Volume I - Summary

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16. Abstract

The National Aeronautics and Space Administration (NASA), recognizing the interplay which exists between the technological and institutional aspects of V/STOL implementation, initiated a system study of the interactive elements to assist in planning V/STOL research, and to determine the V/STOL introduction approach that would reasonably provide for an economically viable V/STOL system.

This study has identified a high density short haul air market which by 1980 is large enough to support the introduction of an independent short haul air transportation system. This system will complement the existing air transportation system and will provide relief of noise and congestion problems at conventional airports. The study has found that new aircraft, exploiting V/STOL and quiet engine technology, can be available for implementing these new services, and they can operate from existing reliever and general aviation airports.

The study has also found that the major funding requirements for implementing new short haul services could be borne by private capital, and that the government funding requirement would be minimal and/or "recovered" through the airline ticket tax. In addition, a suitable new short haul aircraft would have a market potential for $3.5 billion in foreign sales. The long lead times needed for aircraft and engine technology development will require timely actions by federal agencies.

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(Airport requirements)

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(Roles and responsibilities)

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I. INTRODUCTION

Studies of V/STOL (STOL and VTOL) aircraft[1] have pointed out the potential versatility of these concepts in providing convenient intercity service and the benefits of using their powered lift capability to minimize airport size and noise impact on the adjacent communities. While the technological and operational capabilities of the V/STOL aircraft are generally well recognized, their means of introduction as an element in the national transportation system are not clear. In the past, it has been possible for manufacturers and airlines to jointly agree on new aircraft with reasonable confidence that airport and air traffic control facilities would be available and that the aircraft would operate in the normal regulatory environment. The V/STOL aircraft, however, require new facilities in proximity to the population served, creating a new degree of public awareness as well as convenience, possibly necessitating new forms of regulation.

The National Aeronautics and Space Administration (NASA), recognizing the interplay which exists between the technological and institutional aspects of V/STOL implementation, initiated this system study of the interactive elements to assist in planning V/STOL research. The study can also serve as a basis for planning of overall technological and financial needs and the time phasing of major activities.

The objectives of this study were:

- To investigate alternative approaches of introducing V/STOL systems to maximize public benefits within the framework of economic attractiveness for both the operator and the government.
- To define the potential V/STOL market and the logical progression of steps required for the introduction of V/STOL systems.
- To make a preliminary determination of the potential impact of V/STOL systems on other transportation systems.
- To examine the regulatory and environmental questions which may influence the system elements.

To accomplish these objectives it was necessary to define major study element boundaries:

- The aircraft designs are based on NASA contractor studies with technology allowing introduction of STOL in 1980 and an advanced STOL or VTOL in 1990.
- CTOL service will continue in competition with the new short haul air transportation system.
- The high density short haul markets considered are those with distances less than 500 statute miles and with greater than 100,000 air passengers per year in 1970.
- Existing airfields are used for the introduction of STOL service in 1980, and are upgraded as necessary. New ports are included for the introduction of the advanced STOL or VTOL aircraft in 1990.

The resulting technological and institutional interactions were analyzed to determine the V/STOL introduction approach that would reasonably provide for an economically viable V/STOL system. The many elements and interactions considered in the study are illustrated in Figure 1.

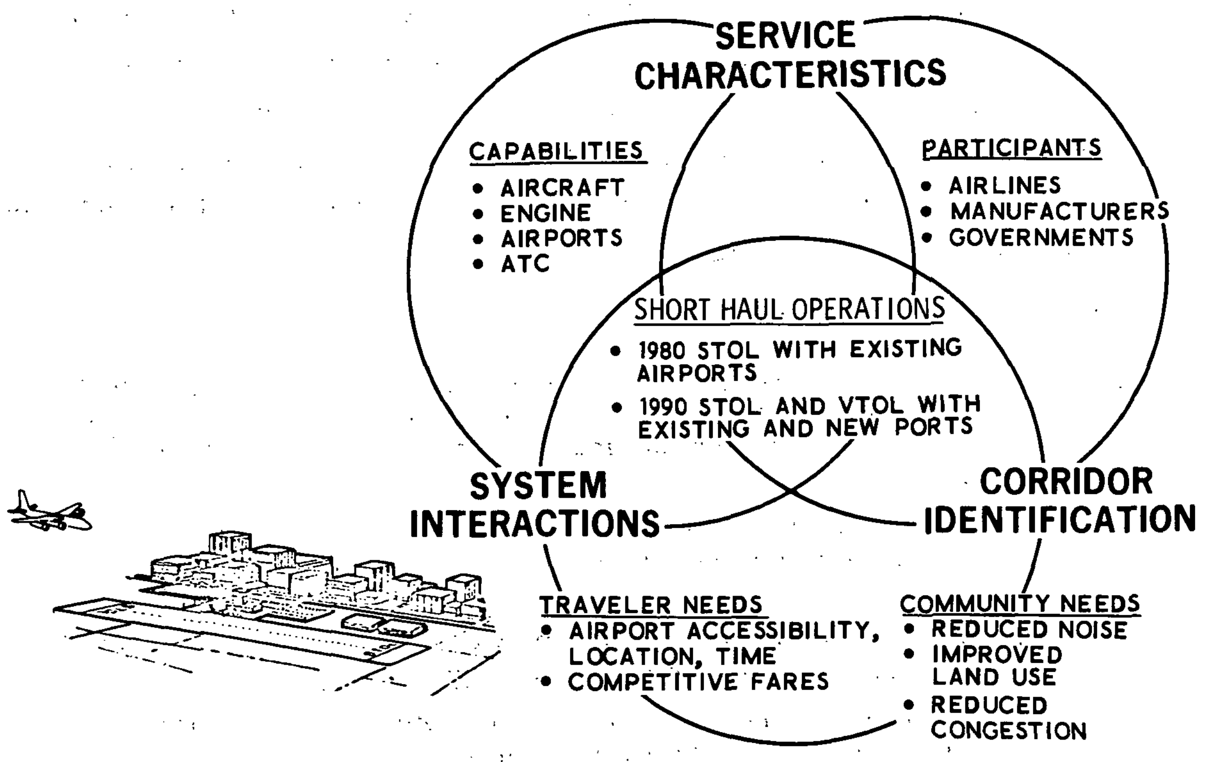


Figure 1. Technological and Institutional Interactions

The body of this report is divided into sections, each addressing one of the major issues that must be answered if a new quiet high density short haul air transportation system is to be implemented. These issues are listed below in their order of presentation in the report:

- What are the high density short haul needs?
- What aircraft technology can be available?
- How many aircraft may be required?
- What are the airport requirements?
- What financial commitments are required?
- Who are the responsible parties and when are the key actions required?

This volume presents a summary of the study. Detailed information concerning methods, results and assumptions is presented in Reference 2.

II. SUMMARY OF RESULTS

This study has identified a high density short haul air market which by 1980 is large enough to support the introduction of an independent short haul air transportation system. This system will complement the existing air transportation system and will provide relief of noise and congestion problems at conventional airports. The study has found that new aircraft, exploiting V/STOL and quiet engine technology, can be available for implementing these new services, and they can operate from existing reliever and general aviation airports.

The study has also found that the major funding requirements for implementing new short haul services could be borne by private capital, and that the government funding requirement would be minimal and/or "recovered" through the airline ticket tax. In addition, a suitable new short haul aircraft would have a market potential for $3.5 billion in foreign sales. The long lead times needed for aircraft and engine technology development will require timely actions by Federal agencies.

A brief summary of some additional study results is presented below.

HIGH DENSITY SHORT HAUL NEEDS

- The passenger demand is expected to double by 1980 and almost double again by 1990.
- The preference for air will continue to increase.
- In 1980 and 1990 multiple air service modes will be required to handle projected demand.
    - This will require new V/STOL service to secondary airports as well as to some new central business district (CBD) ports.
    - It will also require an advanced CTOL system to provide connecting service between CTOLports and for servicing medium density city pairs.
- The use of secondary airports and some new V/STOLports can help relieve the long haul airport congestion.

AIRCRAFT TECHNOLOGY

- The 1980 STOL aircraft appears feasible.
  - The airframe is essentially state-of-the-art.
  - Noise suppression is the key concern with the engine.
  - 1980 is the earliest date for an operational turbofan STOL assuming continuing NASA "Quiet Experimental STOL Aircraft" and "Quiet Clean STOL Experimental Engine" research efforts.
- The 1990 STOL and VTOL aircraft require substantial research in the areas of
  - Composite materials.
  - Further noise suppression.

AIRCRAFT PRODUCTION REQUIREMENTS

- By 1980 at least one replacement aircraft model will be required to supplant the aging 2 and 3 engine jet fleet.
- 300-400 STOL aircraft can be added in both 1980 and 1990 to satisfy domestic needs.
- The foreign market could add 200-275 orders in each time period.

AIRPORT REQUIREMENTS

- 71 secondary airports are needed to support 1980 STOL service to 61 key cities.
- Adequate 3000 ft runways exist at secondary airports to serve 1980 and 1990 STOL needs.
- New STOL terminal facilities are needed at all 71 ports.
- Most affected secondary ports will have the necessary navigation and landing aids when required in the early 1980's.
- The use of quiet STOL aircraft to replace existing 2 and 3 engine CTOL aircraft can cut noise-impacted land area at the reliever airports by 90%.
- VTOL service in 1990 should include the use of CBD facilities.

FINANCIAL NEEDS

- The cost of a V/STOL system to satisfy domestic short haul needs to 1995 is about $7 billion.
- The federal government's share of the start-up costs is about 10% and/or "will be recovered" through the air passenger ticket tax.
- Private funding to 90% of needs should be available as a result of the promising economics of the new service.

ROLES AND RESPONSIBILITIES

The key actions required for implementation of a viable 1980 short haul system are as shown in Figure 2.

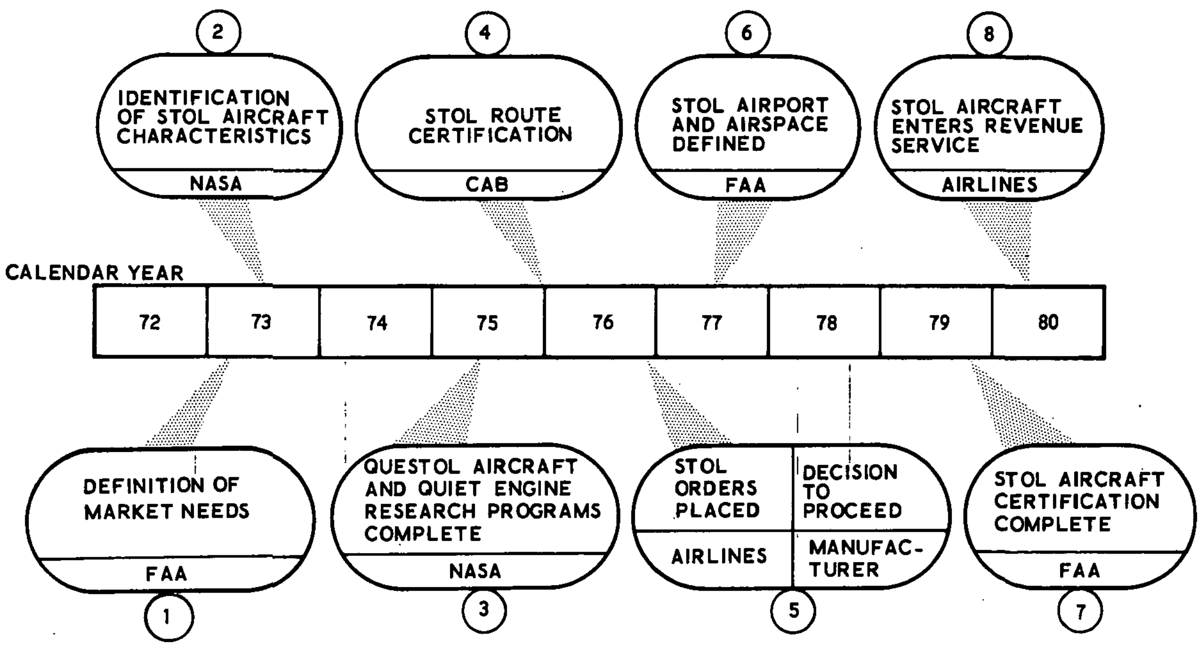


Figure 2. Key Actions for 1980 STOL System

III. SHORT HAUL AIR TRANSPORTATION NEEDS

An examination was made of the present domestic high density short haul air transportation system to establish the nationwide potential for V/STOL (STOL and VTOL) service. The current high density short haul air market was determined along with its relation to the other segments of the U. S. domestic air market. The study included an examination of the air carriers, aircraft, and costs of serving this market. Projections were then made to establish the potential short haul air demand in the 1980 and 1990 time periods.

A. 1970 AIR DEMAND AND SHORT HAUL SERVICE

Domestic air travel can be divided into two markets -- long plus medium haul (over 500 statute miles) and short haul (under 500 statute miles). The air travel market consists of connecting and local air passengers. The connecting passenger requires more than one flight to arrive at his destination which necessitates the use of a hub airport to obtain the connecting flight. The local traveler requires no connecting flight; consequently, he would benefit from the use of smaller airports more conveniently located to his points of origin and destination. The local segment of short haul can be further divided into high density routes (over 100,000 annual origin and destination (O&D) air passengers) and low and medium density routes (less than 100,000 annual origin and destination air passengers). Figure 3 illustrates the 1970 air travel patterns and shows that both the long and medium haul market and the low density short haul market have approximately equal numbers of connecting and local passengers while the high density short haul routes, of which there are only 87, are primarily made up of local travelers which have no need to use the existing congested airports and could be diverted to reliever airports more conveniently located to the traveler.

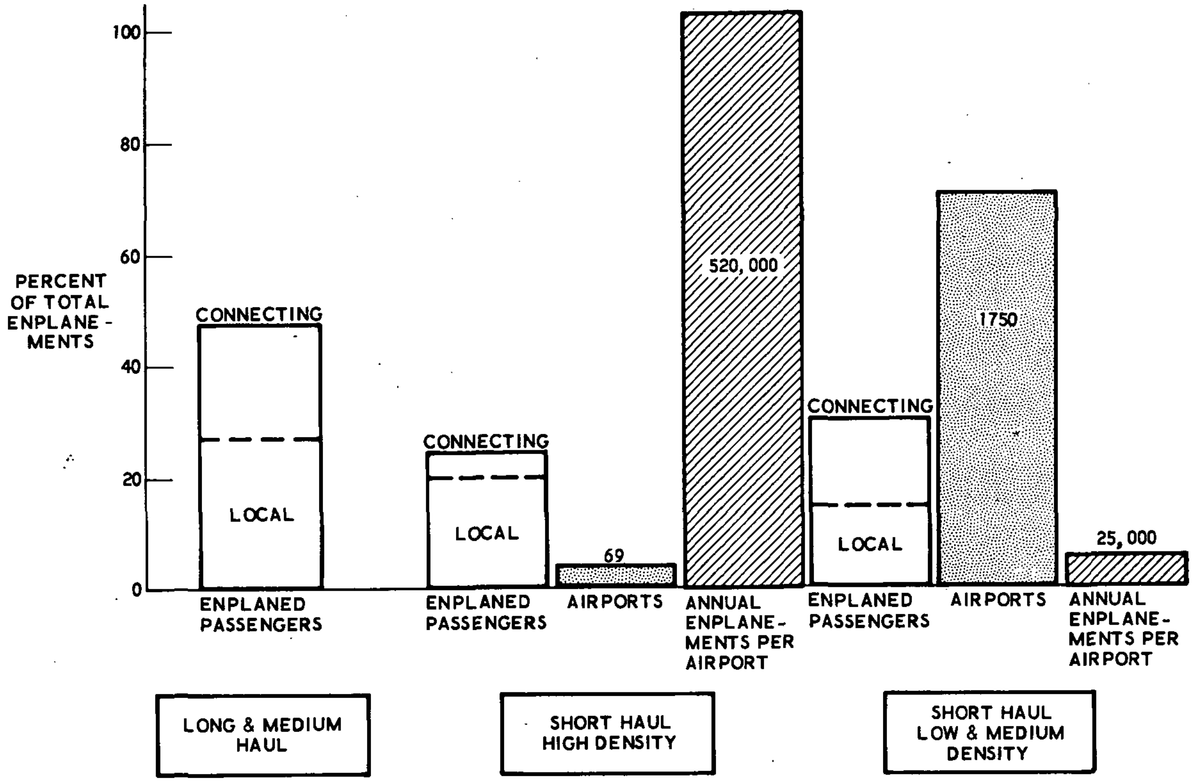


Figure 3. 1970 Domestic Air Travel Patterns

In addition, the high density part of the short haul market is concentrated in 69 airports, whereas the low and medium density half of the short haul market is spread over 1750 U. S. airports. This concentrated high density market averages over one-half million enplanements per airport per year. This high level of enplanements is large enough to allow diversion of several daily flights to conveniently located secondary airports. The low and medium density routes, however, average only 25, 000 enplanements per airport per year. With a 100-passenger aircraft and 50 percent load factor these 25, 000 enplanements would support less than two flights per day and with half of these enplanements requiring connecting flights at long haul hub airports it does not appear to be possible to divert this air traffic to new secondary airports.

REGIONS	CITIES	CITY-PAIRS	AIRPORTS	O&D AIR PASSENGERS	%U.S. TOTAL ENPLANED PASSENGERS
9	61	87	69	30.2 MILLION	20%

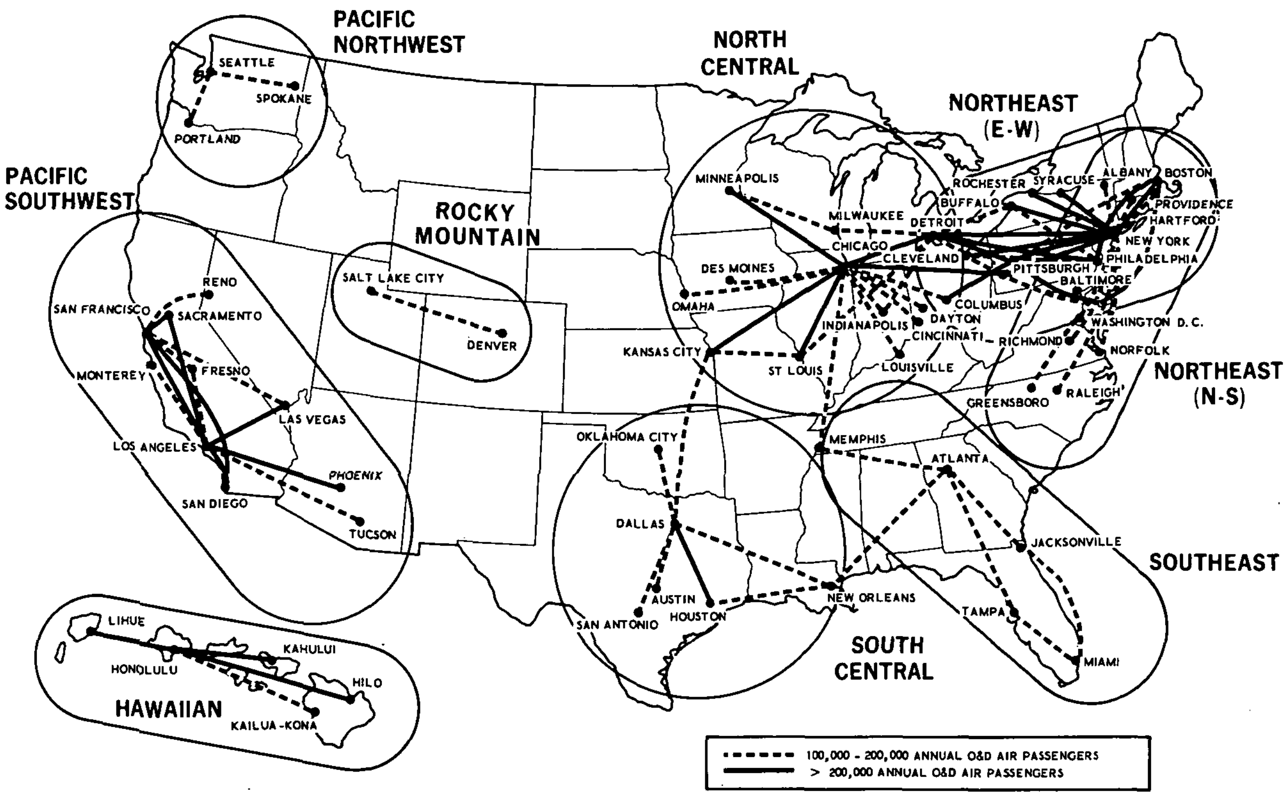


Figure 4. 1970 High Density Short Haul Air Transportation Regions

The 1970 high density short haul air transportation regions are shown in Figure 4. The nine regions cover most of the nation with the local air passengers emanating from 61 cities and 69 airports along 87 routes (city pairs). The routes in the Pacific Southwest Region, the Northeast (N-S) Region, and the Northeast (E-W) Region are primarily unidirectional or corridor type routes while the routes in the North Central, South Central, Southeast, Pacific Northwest, and Hawaiian regions are radial from a hub. The 1970 air demand for each of the nine regions is tabulated in Table 1 and shows that 80% of the high density short haul air O&D is concentrated in four regions: Northeast (N-S), Northeast (E-W), Pacific Southwest, and North Central. Only 17% of the high density short haul travel in 1970 was on average by air with 83% being by other travel modes including automobile, bus and rail.

Table 1. 1970 High Density Short Haul Air Demand

REGION	AIR O & D	PERCENT OF TOTAL AIR O & D	PERCENT OF TOTAL O & D
NORTHEAST (N-S)	6,990,000	23.2	13
NORTHEAST (E-W)	5,280,000	17.5	34
PACIFIC SOUTHWEST	9,630,000	31.9	13
NORTH CENTRAL	4,780,000	15.8	21
SOUTH CENTRAL	1,160,000	3.8	18
HAWAIIAN	1,130,000	3.8	100
SOUTHEAST	710,000	2.3	19
PACIFIC NORTHWEST	370,000	1.2	13
ROCKY MOUNTAIN	120,000	0.4	16
TOTAL	30,180,000	100%	17%

The local high density short haul market appears to be unique in the type of service but currently uses aircraft developed for other service. It would further appear that the market is sufficiently large to support special service and special aircraft. The air carriers and aircraft currently providing service were examined to determine to what extent the market was treated as unique. This also provided the basis to examine the equipment and operational implications as well as the economic factors related to instituting a new class of air carrier service for the local high density short haul market.

An examination of the types of aircraft[3] used in current local high density short haul service indicates that 75% of this service is provided by two- and three-engine jet medium range aircraft. The balance of the

service is provided by four-engine jet aircraft. The domestic trunk airlines, whose prime markets are essentially medium and long haul, provide over 71% of the high density short haul service,[3] while local carriers provide only 19% of the service. The tendency of the carriers is to treat the entire short haul market as a connecting service for the medium to long haul market. The balance of the market, 10%, is served by three intrastate carriers with services and aircraft that are more closely related to the unique nature of this market.

The equipment and service provided by the trunk carriers is reflected in fare levels since the current Civil Aeronautics Board practice is to establish fares based on overall airline costs incurred in the operation of different types of aircraft in all types of markets. As a result the air carriers provide facilities and services and charge fares that are based on the medium to long haul market. These services include food, large terminals to wait for a connecting flight and interflight reservations and ticketing that are not required to satisfy the local high density short haul market. To obtain a viable unique service in this market it is desirable to establish lower fare levels based on the actual cost of the carrier providing the service with optimum aircraft designed for this market and with indirect operating costs tailored to provide only the necessary service for this market.

As mentioned above, the costs of operation of domestic trunk and local service carriers are characterized by operations of large mixed fleets of aircraft serving a variety of markets. The operating costs of the trunk and local service carrier are considerably higher when compared to a carrier whose service is generally limited to the high density short haul markets.[4] Instituting a new single class type service based on the operating characteristics and costs of serving only the high density short haul markets can sharply reduce indirect operating costs.

B. FUTURE V/STOL DEMAND

The methodology used to predict the future high density short haul air demand is illustrated in Figure 5. Future V/STOL demand in the high density market was calculated by projecting the total travel demand by all transportation modes for each of the 87 city pairs and then estimating the share of the market that will be captured by the new short haul V/STOL air service. The future total travel demand for all modes of travel for 1980 and 1990 was developed with a modified gravity model[5] developed by The Aerospace Corporation which predicts future total travel between a given city pair as a function of existing travel and current and future population products. Population data from the 1970 census[6] was used to project the 1980 and 1990 population figures.

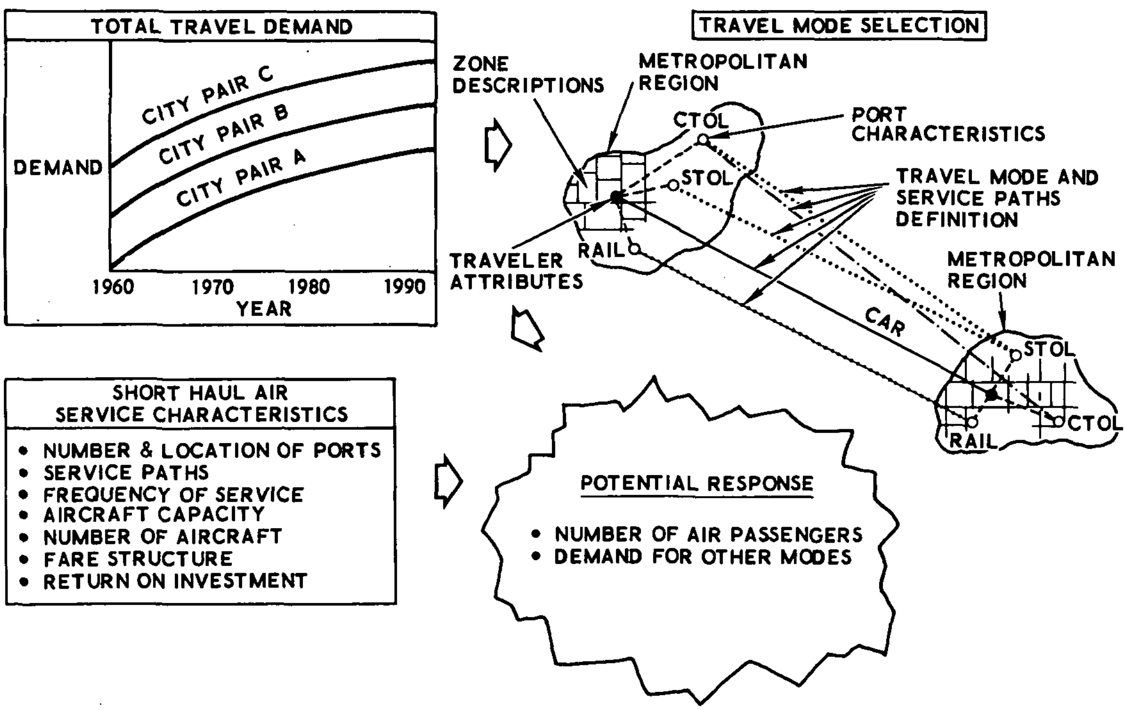
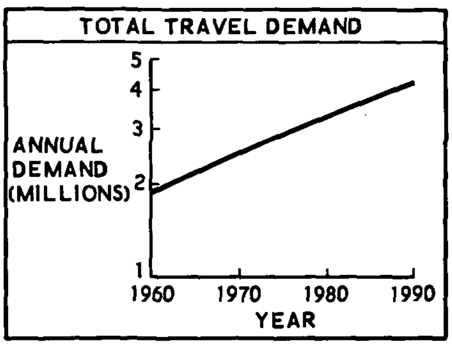
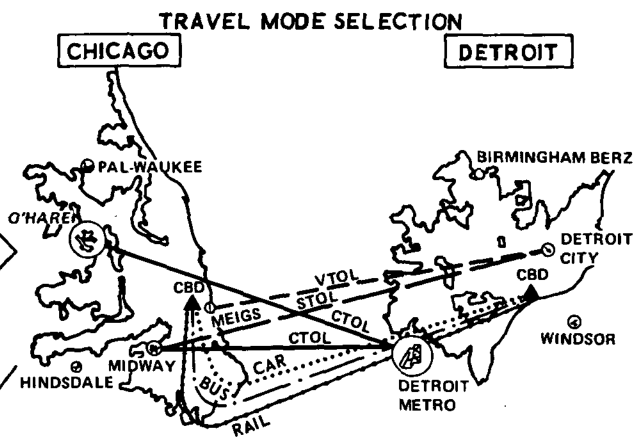


Figure 5. Methodology

The share of the total travel market captured by a particular mode of travel was calculated using the Aerospace modal split program.[5] The program calculates the proportion of travelers who would be expected to select each of the competing modes by generating a statistically adequate number of simulated travelers and modeling the portal-to-portal time and cost decision process of each traveler. The computer program inputs consist mainly of travel data distributions and other descriptive statistics needed to accurately represent travelers, travel arenas, and travel modes including the characteristics of the new short haul air service mode. The output is the potential response (number of passengers) to the new service as well as the passenger demand expected for the other modes.

Each of the 87 city pairs was modeled in this fashion and Figure 6 is an example of the travel demand analysis for the Chicago-Detroit route.





SHORT HAUL AIR SERVICE CHARACTERISTICS

1980
- 2 CENTRAL PORTS
- 1 SERVICE PATH
- 16 DAILY ROUNDTRIPS
- 3 AIRCRAFT
- FARES: $20.00 STOL
  27.00 CTOL

POTENTIAL RESPONSE

MODE	ANNUAL PERSON TRIPS		
	1970	1980	1990
CAR	1,640,000	1,980,000	2,540,000
BUS / RAIL	180,000	130,000	145,000
CTOL	680,000	180,000	290,000
STOL	—	950,000	670,000
VTOL	—	—	520,000

Figure 6. Example of Travel Demand Analysis (Chicago-Detroit)

The total travel demand grows from approximately 2-1/2 million passengers in 1970 to 3-1/4 million in 1980 and over 4 million by 1990. The routes and port locations for each of the competing travel modes are illustrated along with air service characteristics for the new 1980 short haul system. The actual passenger demand is shown for the calibration year of 1970 and the predicted demand for the travel modes in 1980 and 1990. By 1980 the new short haul air system would capture about 30 percent of the total demand with the passengers primarily being diverted from the existing conventional takeoff and landing aircraft (CTOL) service. By 1990 the model results indicate that the demand has expanded sufficiently to support three types of air travel systems -- CTOL, STOL and VTOL.

The local high density air demand for the new short haul service was projected for each of the 87 city pairs for 1980 and 1990 as illustrated for Chicago-Detroit. These results were grouped by region and are presented in Table 2. The high density short haul air demand is seen to double

Table 2. Projected High Density Short Haul Air Demand

REGION	AIR O & D PASSENGERS (THOUSANDS)		
	1970 (ACTUAL)	1980	1990
NORTHEAST (N-S)	6,990	18,380	24,240
NORTHEAST (E-W)	5,280	12,070	16,260
PACIFIC SOUTHWEST	9,630	20,650	25,120
NORTH CENTRAL	4,780	14,230	19,640
SOUTH CENTRAL	1,160	5,080	8,410
HAWAIIAN	1,130	1,810	2,530
SOUTHEAST	710	3,300	5,710
PACIFIC NORTHWEST	370	1,360	2,010
ROCKY MOUNTAIN	120	660	1,020
TOTAL DEMAND	30,180	77,540	104,950
SHARE OF TOTAL DEMAND	17%	29%	32%

between 1970 and 1980 and almost quadruple between 1970 and 1990. The last line of Table 2, the proportion of the total demand captured by the new short haul air system, grows from 17 percent in 1970 to 29 and 32 percent in 1980 and 1990, illustrating the potential attractiveness of new air service.

A better perspective of the growth of the local high density short haul air market can be obtained by comparing the growth of this market segment with the predicted growth of the total air passenger market. The growth in air passenger travel from 1960 to the present along with the projected air passenger growth for both the total domestic market and the short haul market for the 1980-1990 time period are illustrated in Figure 7. The total air passenger market forecast was prepared by the Air Transport Association (ATA),[7] the high density short haul market forecast was prepared as a part of this study, and the total short haul market prediction represents an interpolation of the data using the other two forecasts. These projections show 800 million enplaned air passengers in 1990, up 650 million from the 150 million in 1970. These 800 million air travelers represent a potential market for at least four types of aircraft. The long and medium haul passenger travel grows from 75 million in 1970 to 500 million in 1990 offering much larger markets for a quiet long haul aircraft and a quiet medium haul aircraft. The low density and connecting high density short haul market grows from 50 million in 1970 to 190 million enplaned passengers in 1990 presenting a third market for another quiet aircraft. The local high density short haul market (the potential V/STOL aircraft market) expands from 30 million in 1970 to 105 million enplaned air passengers in 1990. The balance of the study is devoted to the selection and implementation of V/STOL aircraft to serve this last market.

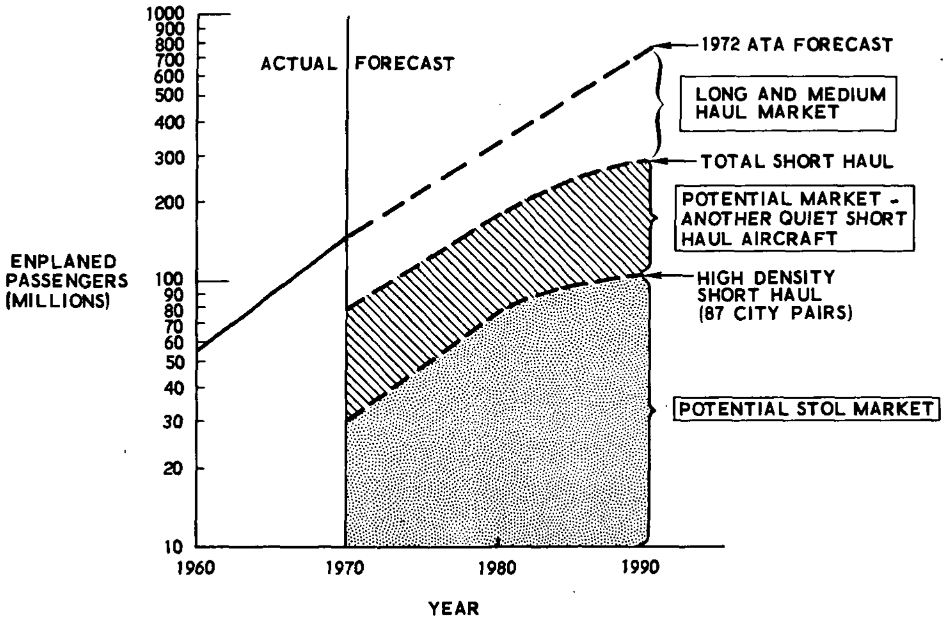


Figure 7. U. S. Domestic Air Travel Growth

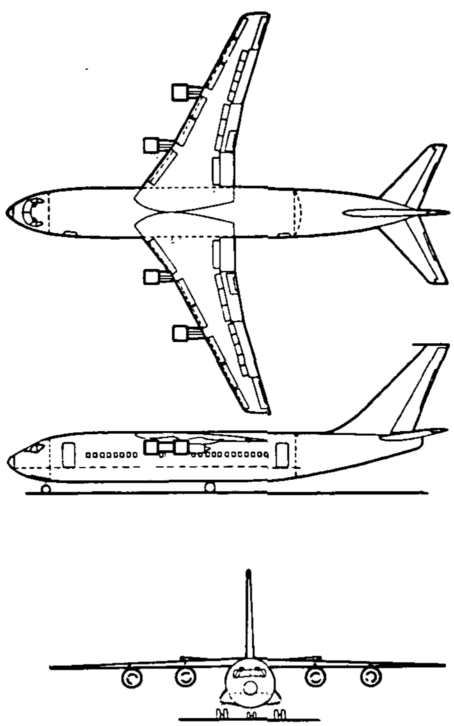
IV. AIRCRAFT TECHNOLOGY

The aircraft design and quiet propulsion technology development may be the pacing item in the introduction of a viable V/STOL short haul air service. The demand for short field performance and reduced noise impact while still maintaining an adequate payload to enable the aircraft to be economically competitive requires a technological advancement in structures and propulsion as well as improved aerodynamic design. The development and engineering schedules for the selected aircraft design depend on the timely availability of this technology. While there are a number of potential design options for V/STOL aircraft, it was decided to select an aircraft design for 1980 that was compatible with existing secondary airports and then for 1990, as more advanced technology became available, develop an advanced STOL or VTOL system to replace the 1980 system.

Determining the potential use of existing airfields to support a short haul STOL system was an objective of the study. When a census of available fields was taken it was found that there were more than sufficient fields available with runway lengths greater than 3000 ft. to meet the requirements of the system. (This is developed further in Section VI.) The result of the availability of runway lengths of 3000 ft. and greater is a reduced demand on aircraft design requirements. The primary effects are concerned with wing loading and rate of sink at touchdown, also on the propulsive lift system in the areas of power loading and wing loading for takeoff.

This reduction in design requirements made it attractive to consider a propulsive lift aircraft design in terms of a minimum evolution from current aircraft technology. The externally blown flap (EBF) propulsive lift concept was selected for its relative simplicity. A current "paper" engine design

capability was modified, in terms of weight, for increased noise suppression. While a high by-pass ratio (12) is used, the engine-nacelle size is still small enough to minimize potential interference drag effects. An all-aluminum structure is used since the utilization of composites to reduce weight is not necessary to achieve a 3000 ft. takeoff and landing capability. The supercritical wing section is used to achieve a cruise Mach number of 0.8 while retaining sufficient wing thickness for fuel storage and efficient structural design. The resulting 1980 externally blown flap (EBF)-STOL design is summarized in Figure 8.



DESIGN CHARACTERISTICS

SIZE:
- CAPACITY: 150 PASSENGERS
- TAKE-OFF GROSS WEIGHT: 122,000 LB

DESIGN FEATURES:
- EBF LIFT AUGMENTATION
- ALL ALUMINUM STRUCTURE
- WING LOADING: 90 PSF
- SUPERCRITICAL WING

ENGINES:
- FOUR 16,600 LB TURBOFAN
- BY-PASS RATIO = 12

PERFORMANCE:
- FIELD LENGTH - 3000 FT
- CRUISE SPEED - 0.8M at 30,000 FT
- NOISE LEVEL - 95 EPNdb at 500 FT
- RANGE - 500 smi

Figure 8. Representative 1980 STOL Aircraft

The use of advanced technology was assumed in the areas of structures and quiet propulsive lift for the 1990 operational aircraft. This provides greatly improved performance with a reasonable aircraft size and weight. The 1990 STOL was designed for a 2000 ft. field length. The wing loading was maintained at the 90 psf used for the 1980 EBF-STOL. The augmentor wing (AW) propulsive lift concept was selected for its apparent superiority of noise suppression. Maximum application of composites (80%) to primary and secondary structure was used to reduce weight and wing area. The supercritical wing section was retained. A cruise Mach number of 0. 9 was selected for both the 1990 STOL and VTOL.

The 1990 VTOL also utilizes the maximum level of composites in the structure. A lift-fan propulsive lift concept was used. The wing platform geometry was changed by increasing the sweep and lowering the aspect ratio. The thickness ratio of the supercritical airfoil was also reduced. These changes were required to meet the 0. 9 M cruise requirement.

A comparison of the takeoff gross weights for the STOL is shown in Figure 9 for the study aircraft and other comparative design studies.[8, 9] The weight comparison indicates reasonable agreement with the other data when the effects of field length, range and fuel reserves are considered.

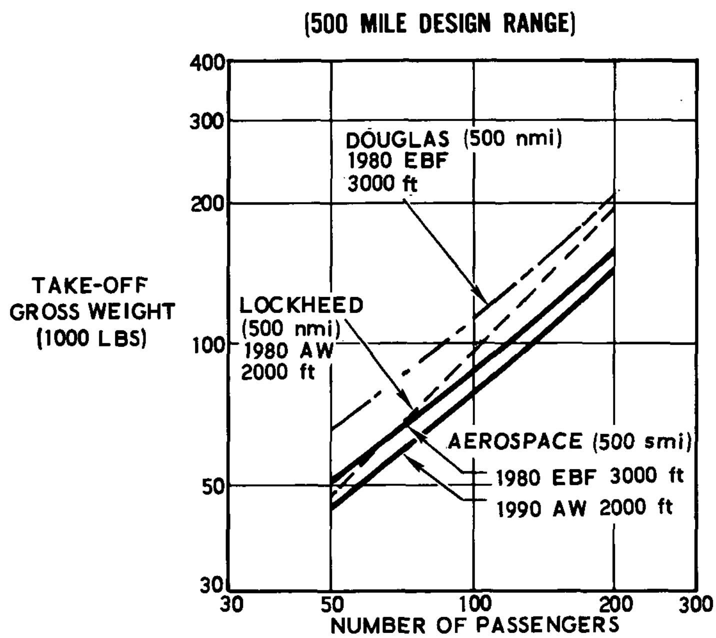


Figure 9. Takeoff Gross Weight of STOL Aircraft

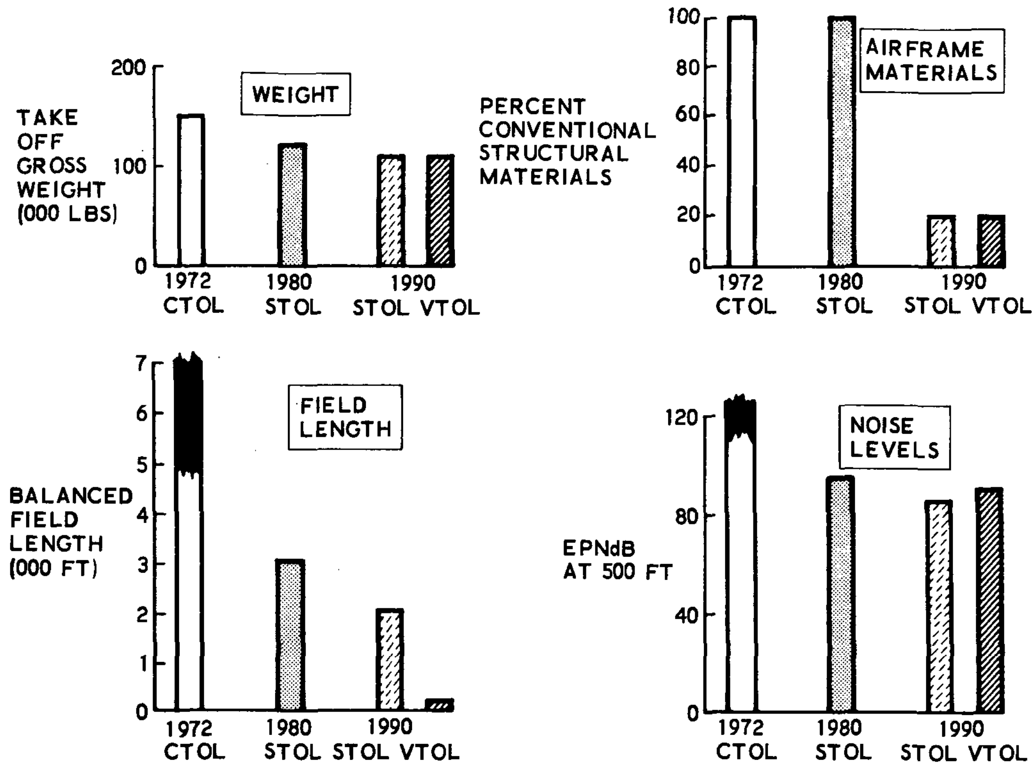


Figure 10. Comparison of Technical Features

A comparison of the technical capabilities for 150-passenger versions of the three study V/STOL aircraft and a 1972 CTOL aircraft is shown in Figure 10. The aircraft takeoff gross weight can be reduced from 150, 000 lbs in 1972 to 110, 000 lbs in 1990. This weight reduction is possible by shifting from the 100% use of conventional materials in 1972 and 1980 to an aircraft structure that is primarily (80%) composed of new lightweight composite materials. At the same time the balanced field length required for takeoff and landing can be reduced from the 5000 to 7000 feet for the 1972 CTOL, to 3000 feet for the 1980 STOL, to less than 2000 feet for the 1990 STOL and finally to only the space required for a landing pad for the 1990 VTOL. The noise levels of the current CTOL run approximately 120 EPNdB

at 500 feet. It is estimated that these levels can be reduced to 95 EPNdB for the 1980 STOL, 85 EPNdB for the 1990 STOL and 90 EPNdB for the 1990 VTOL. A major technology effort will be required in this area of noise suppression. The achievement of the desired noise levels will require the full implementation of most of the noise suppression techniques now under consideration and study by NASA and may not prove adequate in all cases. The 1980 EBF-STOL, in particular, will require the full use of acoustic materials and detuning techniques for internal noise suppression. The reduction of external noise will required reduced scrubbing by lowering the engine exhaust velocities to reduce the noise caused by the impingement of the high velocity exhaust on the externally blown flaps. Again, it is not clear that this will be adequate to reach the desired noise level. The 1990 STOL augmentor wing concept to some appears to be more promising, but in addition to the internal treatment, a sonic inlet is required as is a special design for the augmentor nozzle including screech shields. The VTOL lift fan requires full quieting on the cruise engines plus quieting for the lift fans and the driving gas generators. Noise impact effects have been generated on the basis of the desired noise levels; however, a major NASA funded research and development effort is required to approach these levels.

While the selection of the 1980 EBF-STOL aircraft design characteristics was predicted on minimum technological impact for propulsive lift, it is the quiet propulsion technology that will be the pacing item for a 1980 operational capability. Figure 11, "STOL Aircraft Milestones," gives an example of the time required for development, production, test and introduction of the 1980 STOL. This timeline represents the period required to develop the required technology with the NASA Quiet Experimental STOL Aircraft (QUESTOL) and the NASA Quiet Clean STOL Experimental Engine (QCSEE), plus time equivalent to that required for the DC-10 development with about one year allowed for the introduction of the completely new STOL system. The 1976 date for the QCSEE is for operation of an initial engine design. This does not leave time for an extensive modification and qualification program. While the overall schedule compares well with the DC-10 schedule, the latter represents a particularly efficient and effective development to operations schedule implementation.

	1972	1973	1974	1975	1976	1977	1978	1979	1980
NASA QUIET ENGINE									
START DEVELOPMENT	▲								
1st ENG DELIVERY					▲				
NASA QUESTOL DEVELOPMENT									
CONTRACT AWARD	▲								
1ST A/C DELIVERY			▲						
2ND A/C DELIVERY				▲					
COMMERCIAL A/C DEVELOPMENT									
AUTHORITY TO PROCEED					▲				
START MANUFACTURING						▲			
FLT TEST 1ST A/C							▲		
FAA CERTIFICATION								▲	
INTRO INTO REV SERVICE									▲

	1968	1969	1970	1971	1972
DC-10 AIRCRAFT DEVELOPMENT CYCLE					
AUTHORITY TO PROCEED	▲				
START MANUFACTURING		▲			
FLT TEST 1ST A/C			▲		
FAA CERTIFICATION				▲	
INTRO INTO REV SERVICES				▲	

Figure 11. STOL Aircraft Milestones

V. AIRCRAFT PRODUCTION ESTIMATES

The ultimate production quantities of STOL and VTOL aircraft are dependent upon the fleet size required to meet the domestic market demand and the international demand. The rate at which the V/STOL aircraft are required is a strong function of the termination of service life of existing airline equipment now serving this market. The STOL fleet size required to serve the short haul, high density U. S. domestic market will be dependent upon aircraft size, performance and utilization. The overseas sales potential of V/STOL aircraft can increase the production requirement and thereby decrease the unit cost.

A. CURRENT FLEET REPLACEMENT

The successful introduction of a new aircraft into the short haul high density market is dependent not only on the potential demand but also on the air carrier's ability to purchase new equipment. At the present time approximately 75% of the short haul high density market is served by two- and three-engine jets and 25% by other aircraft.[3] Figure 12 illustrates the time dependent composition of jet aircraft fleet owned by U. S. air carriers. The widebodied jets designed to serve the long haul routes are replacing the four-engine jets currently serving this market only eleven years after their introduction into service. However, if a conservative 15-year depreciation period is assumed, replacements will be required for the two- and three-engine short and medium haul aircraft starting in 1978. The figure shows that there will be a need to purchase about 1200 new aircraft to serve both the medium and short haul market on the basis of a simple one-for-one aircraft replacement.

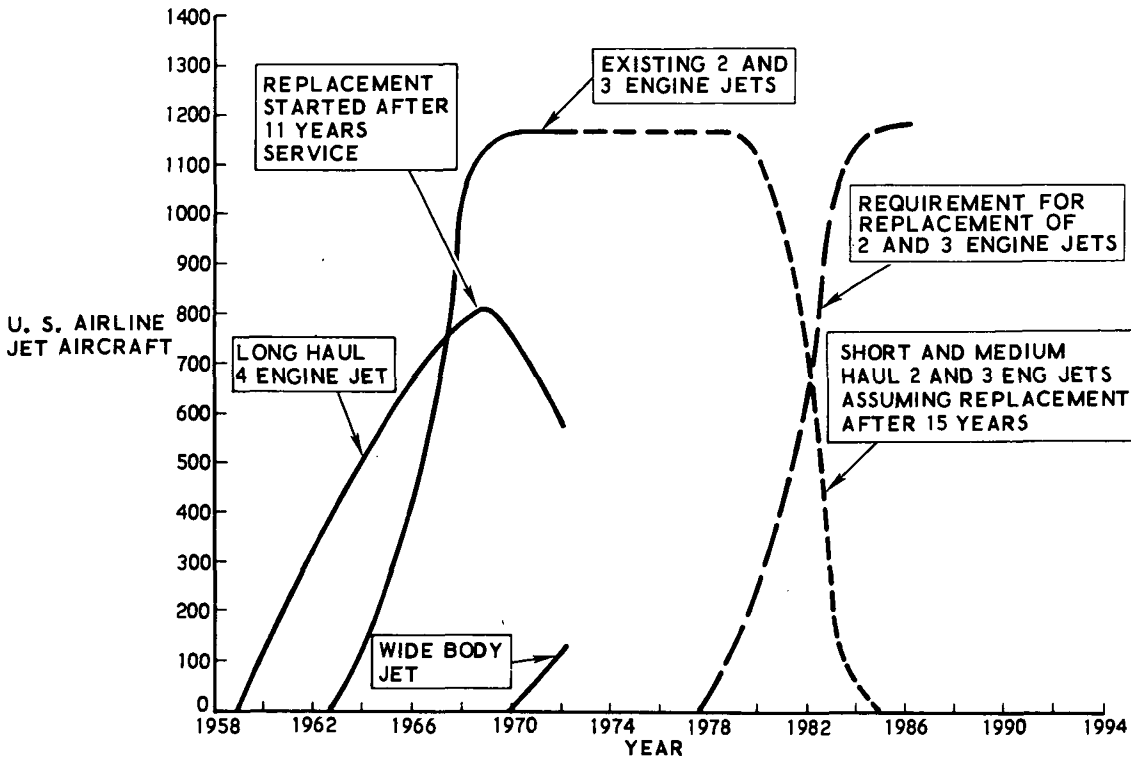


Figure 12. U. S. Airline Jet Aircraft

B. DOMESTIC HIGH DENSITY SHORT HAUL REQUIREMENTS

The methodology used to determine the number of STOL aircraft needed to serve the high density short haul market (87 city pairs) is based on an examination of the market potential on the basis of competition and potential growth. Figure 13 identifies the factors considered for the competitive and non-competitive markets along with the factors used for maximum and minimum potential growth. The degree of market competition was used as an index to determine aircraft passenger load factor. When two or more carriers operate in competition the load factor is lower with the CAB experience[10] indicating a 55% load factor under these conditions. However, when an air carrier has no competition on a route about 65% is achievable.

- ON BASIS OF COMPETITION:
  - COMPETITIVE
    - TWO OR MORE CARRIERS
    - CAB EXPERIENCE SHOWS 55% L.F. HISTORY
    - INCREASED SERVICE SHOWS LESS PROFITABILITY
  - NON - COMPETITIVE
    - EXCLUSIVELY ONE AIR CARRIER
    - CAB EXPERIENCE SHOWS HISTORY OF 65% L.F. OPERATIONS
    - MOST PROFITABLE AND ALLOWS LOWEST FARE
- ON BASIS OF POTENTIAL GROWTH
  - MINIMUM GROWTH (STATUS QUO)
    - MODEST GROWTH RATE
    - FARES REMAIN STABLE
    - FEW ADDITIONAL SERVICE PATHS
  - MAXIMUM GROWTH
    - HIGH GROWTH RATE
    - LOWER FARES
    - MORE SERVICE PATHS AND STOLPORTS

Figure 13. Classification of High Density Short Haul Markets

For the minimum growth market STOL fares were selected equal to existing CAB coach fares and for the maximum market the fares selected are equal to the proposed STOL interstate fares discussed in Section V. C. In addition to the competition and growth factors, aircraft utilization and aircraft size were treated as variables. The number of flights which can be flown by one aircraft serving a given city pair was calculated as a function of the aircraft block time for the intercity trip and annual utilizations of 2500, 3000, and 3500 hours per year. The aircraft utilization of 2500 hours per year is characteristic of that currently achieved by carriers serving the short haul high density market.[4] The higher utilizations of 3000 and 3500 hours represent the range of utilizations which may be achieved assuming specialized service and improvements in operating efficiency.

Tables 3, 4 and 5 show the variation in fleet requirements for the 1980 STOL, the 1990 STOL with no VTOL, and the 1990 VTOL with no STOL, respectively. These fleet requirements include 10% spares. The largest aircraft requirement results from a maximum growth competitive market and 2500 hours a year utilization of a 50-passenger aircraft. This would require 980 STOL aircraft in 1980 and 1170 STOL aircraft in 1990 assuming no VTOL aircraft, or 1035 VTOL aircraft in 1990 assuming no STOL aircraft. The minimum aircraft requirements result from the minimum growth competitive market with 3500 hours per year utilization of a 200-passenger aircraft. This requires 125 STOL aircraft in 1980, 150 STOL aircraft in 1990 (assuming no VTOL) or 130 VTOL aircraft in 1990 (assuming no STOL).

To simplify the costing and determination of the airport requirements only one set of fleet parameters was considered in the balance of the study. The selected set, shown as shaded values in the tables, was the 150-passenger STOL and 100-passenger VTOL aircraft in a competition maximum growth market with aircraft utilizations of 2500 hours per year. The 150-passenger STOL capacity was selected based upon results[5] which indicated the 150-passenger aircraft was a good nominal size and upon the current success with intrastate short haul high density operators using a 150-passenger capacity aircraft.[4] The 100-passenger size VTOL was selected on the basis of a lower development risk for 1990. The aircraft quantities for this set of parameters are summarized in Table 6, along with potential aircraft quantities for a mixed fleet of VTOL and STOL aircraft beginning in 1990. The proportion of the mixed fleet that is VTOL was determined by the modal split analysis charging a 10% fare premium for VTOL over STOL. Over 300 STOL aircraft will be required in both 1980 and 1990 and if the STOL vehicle were replaced by a VTOL aircraft in 1990 over 500 VTOL aircraft could be required. However, by 1990 the market appears large enough to support a mixed fleet of STOL and VTOL aircraft.

Table 3. 1980 STOL Fleet Requirements

ANNUAL UTILIZATION (HRS)	AIRCRAFT CAPACITY (SEATS)	COMPETITIVE MARKET 55% LOAD FACTOR		NON-COMPETITIVE MARKET 65% LOAD FACTOR	
		MINIMUM GROWTH	MAXIMUM GROWTH	MINIMUM GROWTH	MAXIMUM GROWTH
2500	50	700	980	720	910
	100	350	490	360	455
	150	230	325	240	300
	200	175	245	180	225
3000	50	580	815	600	760
	100	290	410	300	380
	150	195	300	220	260
	200	145	205	150	190
3500	50	500	700	515	650
	100	250	350	260	325
	150	165	235	170	215
	200	125	175	130	160

Table 4. 1990 STOL Fleet Requirements (No VTOL)

ANNUAL UTILIZATION (HRS)	AIRCRAFT CAPACITY (SEATS)	COMPETITIVE MARKET 55% LOAD FACTOR		NON-COMPETITIVE MARKET 65% LOAD FACTOR	
		MINIMUM GROWTH	MAXIMUM GROWTH	MINIMUM GROWTH	MAXIMUM GROWTH
2500	50	830	1170	860	1090
	100	415	585	430	545
	150	280	390	285	365
	200	210	295	215	270
3000	50	690	980	715	905
	100	345	490	360	455
	150	230	325	240	300
	200	175	245	180	225
3500	50	590	840	610	775
	100	295	420	305	390
	150	200	280	205	260
	200	150	210	150	195

Table 5. 1990 VTOL Fleet Requirements (No STOL)

ANNUAL UTILIZATION (HRS)	AIRCRAFT CAPACITY (SEATS)	COMPETITIVE MARKET 55% LOAD FACTOR		NON-COMPETITIVE MARKET 65% LOAD FACTOR	
		MINIMUM GROWTH	MAXIMUM GROWTH	MINIMUM GROWTH	MAXIMUM GROWTH
2500	50	740	1035	760	960
	100	370	520	380	480
	150	245	345	250	320
	200	185	260	190	240
3000	50	615	865	630	800
	100	310	430	315	400
	150	205	290	210	270
	200	155	215	160	200
3500	50	525	740	540	685
	100	265	370	270	345
	150	175	245	180	230
	200	130	185	135	170

Table 6. Estimated Domestic V/STOL Aircraft Requirements

AIRCRAFT TYPE	NUMBER OF SEATS	NO. OF AIRCRAFT REQUIRED
STOL ONLY		
1980 STOL	150	325
1990 ADVANCED STOL	150	390
VTOL ONLY		
1990 VTOL	100	520
1990 MIXED FLEET		
ADVANCED STOL (60%)	150	230
VTOL (40%)	100	210

C. DEMAND SENSITIVITY AND OPERATING COSTS

The demand sensitivity analysis considered the aircraft economics including flyaway costs, direct operating costs, indirect operating costs, and return on investment.

The flyaway cost for the 1980 STOL was developed as a state-of-the-art design for that time period with the exception of engine noise reduction. A Rand Corporation procedure[11] was used to establish engine development cost as a function of time period. This was modified to account for the noise reduction cost effects as a part of engine technology. This resulted in an aircraft flyaway cost of slightly over $8 million for a 150-passenger STOL aircraft weighing 122,000 lbs at takeoff.

The direct operating costs (DOCs) were generated using the modified Air Transport Association model[12] incorporating the 1980 STOL flyaway costs. The DOCs estimated for the 150-passenger 1980 STOL aircraft are compared with the DOCs for the current 150-passenger 727-200 aircraft[4,13] in the upper left of Figure 14 as a function of stage length. These data represent an annual utilization of 2500 hours, 55% load factor, and a STOL aircraft production base of 325. The data show the STOL aircraft having a higher direct operating cost than the 727-200 at all stage lengths.

The indirect operating costs (IOCs) for the high density short haul market were developed assuming a relatively austere operation typified by some current short haul intrastate carriers. The reduction or elimination of services not necessary for the short haul passenger can result in a significant reduction in IOC. Two IOCs are shown in the lower right of Figure 14. The first is the actual IOC of an intrastate carrier[4] operating in the high density short haul market, and the second IOC was developed from interstate trunk carrier IOCs,[12] deleting such cost items as meals and interflight ticketing and reducing the cost allocation for items such as baggage handling. The existing intrastate IOC is the lower of the two IOCs at all stage lengths.

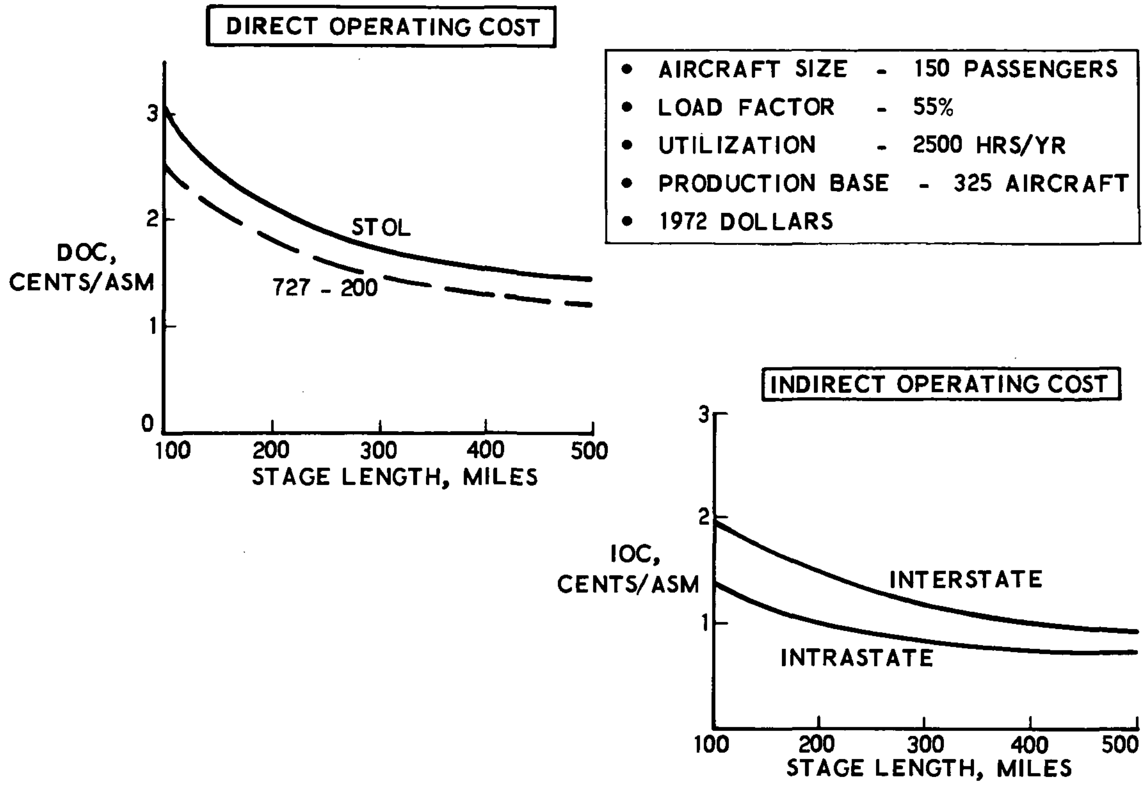


Figure 14. Operating Costs

Two levels of return on investment (ROI) were used in the study. Twelve percent ROI allowed by the CAB was used to calculate interstate fares while a ten-and-one-half percent ROI based on the California Public Utilities Commission practice was used to calculate the intrastate ROI.

In the upper left of Figure 15 four fare levels are shown as a function of stage length and to the lower right of Figure 15 the air modal split is shown for each of four fare levels for the Chicago-Detroit STOL route in 1980. The highest fare is the existing CAB coach fare and the lowest is the equivalent California intrastate fare. The two intermediate fare levels are the STOL interstate fare which is less than the CAB interstate level due to the lower IOCs and second, the STOL intrastate fare which is slightly higher

than the existing intrastate levels due to the higher DOCs of the STOL aircraft. Both STOL fares are based on the STOL DOC and the two IOCs developed for Figure 14.

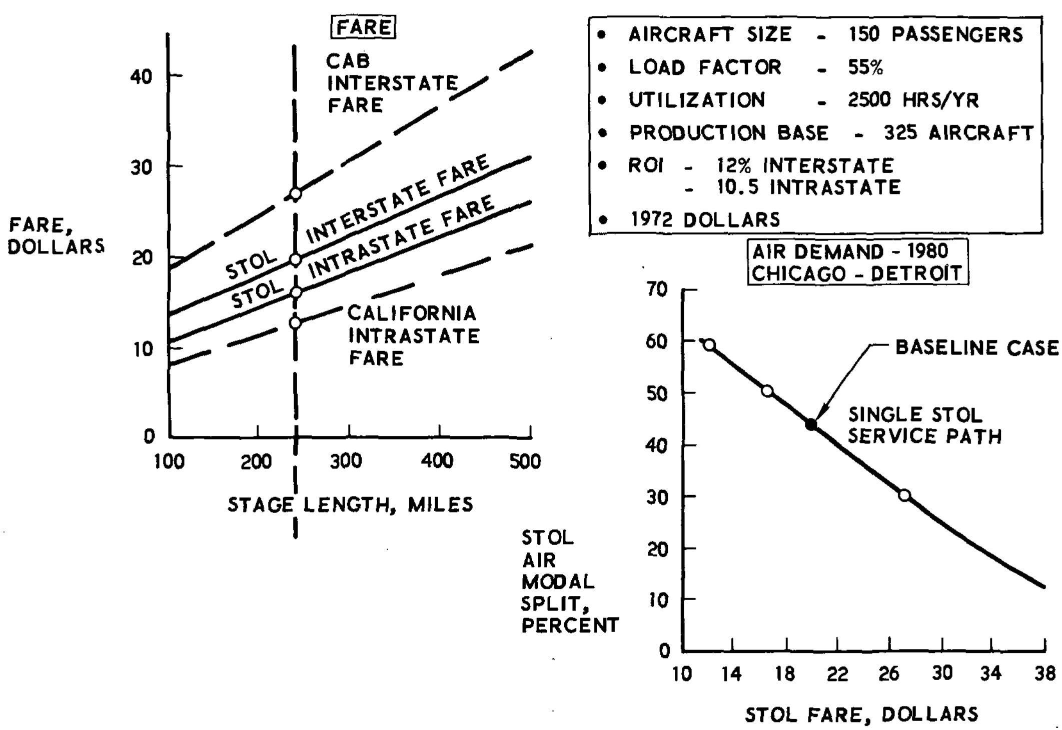


Figure 15. Fare Effect on Air Demand

The air passenger demand sensitivity to fare (air modal split) is shown for each of the four fare levels with 30, 42, 50 and 60 percent of the total travel demand being captured by the STOL system as the fares are reduced.

Sensitivity studies (Figure 16) were made for the 150-passenger 3000 foot 1980 STOL aircraft to determine the sensitivity of aircraft production quantities to certain parameters. The first three parameters illustrated in Figure 16 show the sensitivity of fare to aircraft weight, design cruise speed and cruise altitude, and number of aircraft manufactured, while the last curve in the lower right of Figure 16 shows the variation in the number of STOL aircraft required for the U. S. domestic high density short haul market as a function of fare level.

These data show a 20,000 lb increase in aircraft weight would necessitate a 5% increase in fare, reducing the passenger demand and causing a corresponding reduction in aircraft quantities required from 325 to 303. Similarly, a reduction in aircraft cruise speed and cruise altitude from M = 0.8 at 30,000 feet to M = 0.7 at 20,000 feet would necessitate a 7% increase in fare with the resulting aircraft production requirement reduced from 325 to 300 aircraft for the U. S. domestic market. The sensitivity results indicate that the aircraft quantities forecast for the 1980 short haul market will probably not vary significantly from the quantities identified in the baseline case.

D. INTERNATIONAL DEMAND FOR V/STOL

The potential demand for STOL or VTOL aircraft by foreign carriers was estimated based on the sales pattern of past U. S. built jet aircraft.[14] Table 7 illustrates the domestic and foreign sales for two, three, and four-engine U. S. built jet aircraft. The overall split for these aircraft is 40% foreign and 60% domestic sales. This 60%, 40% division of the total jet aircraft sales was used to estimate the number of aircraft required for the foreign high density short haul market.

Table 8 lists the potential fleet size requirements for the STOL and VTOL aircraft for both the domestic and the combined domestic plus foreign markets. The comparison of the domestic market to the combined domestic plus foreign market shows that 200 to 300 aircraft may be required to satisfy the foreign market.

150 PASSENGER, 3000 ft TAKEOFF AND LANDING, EXTERNALLY BLOWN FLAP, M_{CR} = 0.8 55% LOAD FACTOR, 2500 hr/yr

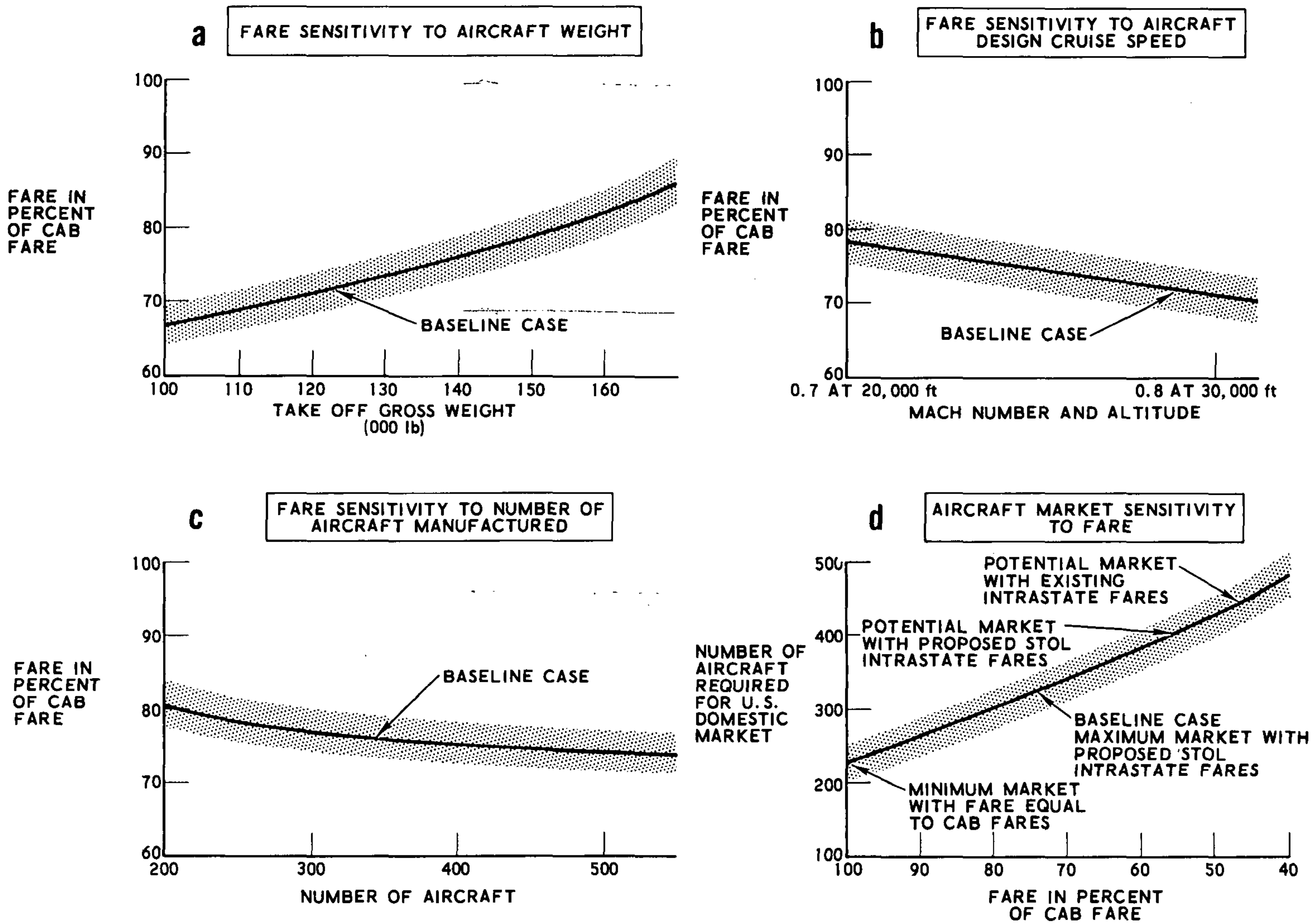


Figure 16. Sensitivity Analysis

Table 7. U.S. Built Jet Aircraft Sales

	AVERAGE** UNIT PRICE $ Millions	SALES		
		TOTAL UNITS*	U. S. MARKET (%)	FOREIGN MARKET (%)
4 ENGINE				
BOEING 707/720/320	9.7	864	55	45
McDONNELL DOUGLAS DC-8	9.0	556	53	47
CONVAIR 880/990	8.7	101	68	32
BOEING 747	25.0	210	55	45
4 ENGINE SUBTOTAL		1731		
3 ENGINE				
BOEING 727	7.6	981	69	31
McDONNELL DOUGLAS DC-10	16.0	240	60	40
LOCKHEED L-1011	16.0	147	90	10
3 ENGINE SUBTOTAL		1368		
2 ENGINE				
McDONNELL DOUGLAS DC-9	5.0	701	54	46
BOEING 737	5.0	332	50	50
2 ENGINE SUBTOTAL		1033		
TOTAL		4132	60	40

* DELIVERIES + ORDERS + OPTIONS

**1972 DOLLARS

Table 8. Estimate of Combined Domestic and Foreign V/STOL Aircraft Requirements

AIRCRAFT TYPE	NUMBER OF SEATS	NO. OF AIRCRAFT REQUIRED	
		DOMESTIC	DOMESTIC PLUS FOREIGN
STOL ONLY			
1980 STOL	150	325	540
1990 ADVANCED STOL	150	390	650
VTOL ONLY			
1990 VTOL	100	520	870
1990 MIXED FLEET			
ADVANCED STOL (60%)	150	230	380
VTOL (40%)	100	210	350

VI. AIRPORT AND AIR TRAFFIC CONTROL REQUIREMENTS

The primary objectives for the introduction of a STOL or VTOL short haul air transport service are increased passenger convenience, time savings and cost savings. These advantages can result from a combination of improved airport access, rapid terminal processing, and reduced air traffic congestion. An important consideration, other than passenger convenience, is the potential for noise reduction at reliever airports due to quiet STOL operations. This section addresses a number of airport-oriented considerations for effective STOL or VTOL introduction. These topics in the order considered are STOLport requirements for passenger convenience, availability of existing airports, STOLport facilities, quiet STOL system benefits, and air traffic control requirements.

A. STOLPORT REQUIREMENTS FOR PASSENGER CONVENIENCE

The approach used in estimating the number of reliever ports needed for passenger convenience in a large metropolitan area was based on an analysis of the need for multiple ports and flight paths to support new short haul service in the California Corridor and the Midwest.[5] The approach is illustrated by data for city pair examples given in Table 9. The number of reliever ports in each of the cities and the STOL service paths between the cities are increased until the travel demand by STOL reaches a point of diminishing return (shaded values) which suggests a practical STOLport requirement. Curves that can be applied to any city pair are obtained when the requirements resulting from this analysis are plotted as a function of daily air passengers, as shown in Figure 17.

Table 9. 1980 STOLport Requirements based on Passenger Convenience

LOS ANGELES-SAN FRANCISCO
19,000 DAILY AIR PASSENGERS

NUMBER OF STOLPORTS		NUMBER OF STOL SERVICE PATHS	PERCENT OF TOTAL TRAVEL DEMAND BY STOL
LOS ANGELES	SAN FRANCISCO		
4	4	16	36.0
4	3	10	35.7
4	3	7	34.3
2	2	4	30.5
2	2	2	24.2
1	1	1	20.4

CHICAGO-DETROIT
4,200 DAILY AIR PASSENGERS

NUMBER OF STOLPORTS		NUMBER OF STOL SERVICE PATHS	PERCENT OF TOTAL TRAVEL DEMAND BY STOL
CHICAGO	DETROIT		
2	3	4	42.0
2	2	3	41.6
1	2	2	41.2
2	1	2	41.2
1	1	1	40.0

CHICAGO-CLEVELAND
2,500 DAILY AIR PASSENGERS

NUMBER OF STOLPORTS		NUMBER OF STOL SERVICE PATHS	PERCENT OF TOTAL TRAVEL DEMAND BY STOL
CHICAGO	CLEVELAND		
2	2	3	47.0
2	1	2	47.0
1	1	1	45.0

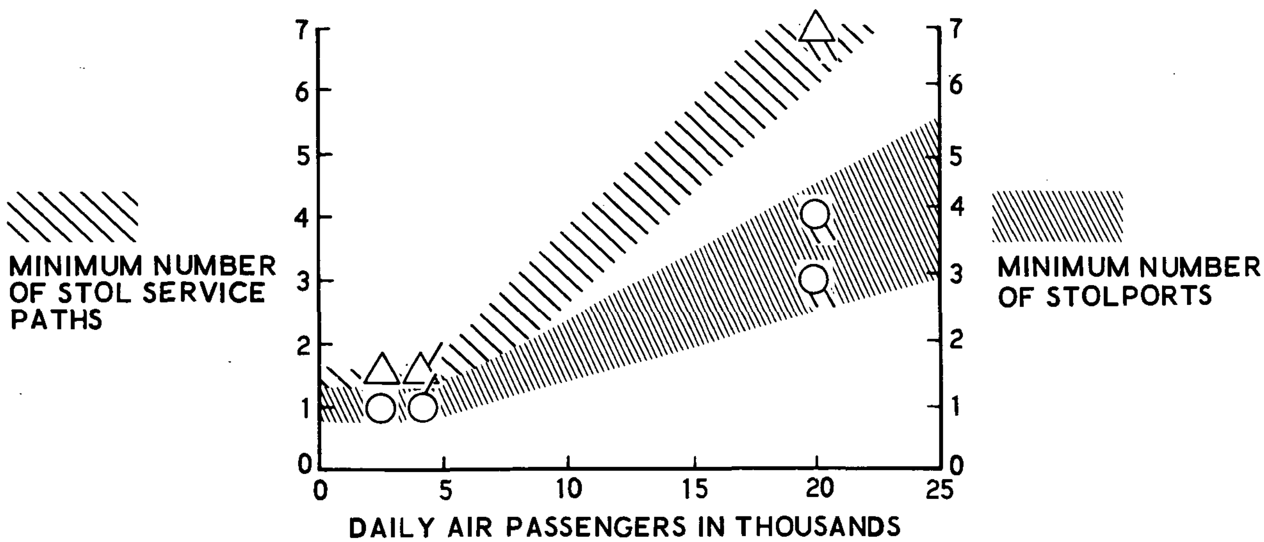


Figure 17. 1980 STOLport and STOLpath Requirements for Passenger Convenience

B. AVAILABILITY AND SELECTION OF EXISTING AIRPORTS

The availability of airports[15] was considered for each of the 61 study cities by examining those airports that lie inside the radius encompassing the entire urban developed area. Four hundred and seventy-two airports were found within these radii, and 269 of these airports had at least one runway longer than 3000 ft. Only 8 of the 472 airports could be considered central business district (CBD) ports. The cumulative distribution of the longest runway lengths available for the 472 airports is shown in Figure 18. These data show that 57% of the runways are greater than 3000 ft in length while only 10% of the runways are 2000 ft or less in length. In addition, most of the 2000 ft or less runways represent general aviation strips with lightweight runways located in the more undeveloped sections of the urban area.

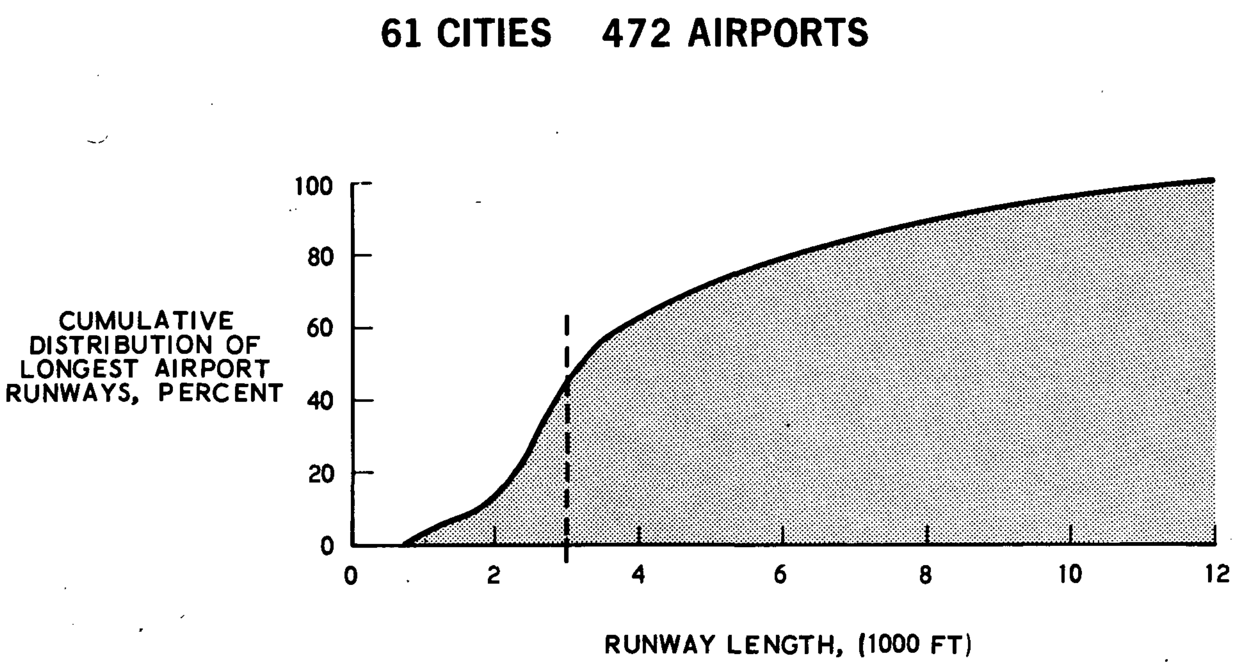
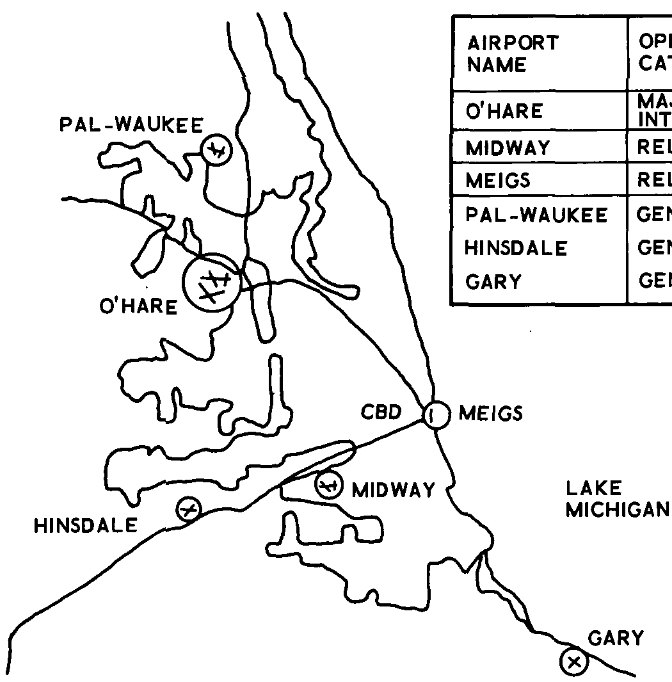


Figure 18. Length of Longest Runways

The study has attempted to describe a typical city airport system that would allow for increased CTOL operations plus new STOL and VTOL operations utilizing existing airports assuming a favorable public response to the need. A desirable urban area airport system will have a major CTOL airport to handle domestic and international long haul and their connecting traffic, one or more reliever airports for handling the local short haul air traffic and a CBD VTOL or STOLport for city center short haul service. This urban area airport system concept is currently capable of development in the Chicago area as illustrated in Figure 19. O'Hare, Midway and Meigs provide CTOL, reliever STOL and CBD-STOLports, respectively. Additional airports are available, as shown, but are less desirable to the high density short haul air traveler than the airports selected; however, the other airports would provide for future growth when this becomes necessary.



CHICAGO

AIRPORT NAME	OPERATIONAL CATEGORY	REMARKS
O'HARE	MAJOR INTERNATIONAL	AT CAPACITY
MIDWAY	RELIEVER	CONVENIENT SHORT-HAUL SITE
MEIGS	RELIEVER	CBD SHORT-HAUL SITE
PAL-WAUKEE	GENERAL AVIATION	OTHER SITES AVAILABLE TO BE UPGRADED FOR FUTURE
HINSDALE	GENERAL AVIATION	
GARY	GENERAL AVIATION	

NATIONWIDE

OPERATIONAL CATEGORY	NUMBER SELECTED
MAJOR INTERNATIONAL	1
MAJOR DOMESTIC	11
RELIEVER	43
GENERAL AVIATION	16
TOTAL	71

Figure 19. Typical Urban Airport System
Chicago Example

The available urban area airports for each of the high density short haul cities were examined and a system selected for each. Seventy-one airports were selected for the nationwide STOL system. These airports are summarized by operational category in the sub-table of Figure 19. Table 10 summarizes the existing airports for each city of the 87 city pairs, including the air demand for both 1980 and 1990. The airports selected for the 1980 STOL system meet the minimum public convenience criteria previously discussed, have a runway bearing strength capable of handling a 150, 000 pound tandem gear STOL aircraft and all the runways are 3000 ft or greater in length. This selection does not eliminate any existing CBD airports.

Table 10. Summary of Existing Airports

CITY PAIR		DAILY AIR PASSENGERS		NUMBER OF CBD AIRPORTS	NUMBER OF URBAN AIRPORTS	
		1980	1990		TOTAL	≥3,000 FT
LOS ANGELES		19,008	21,013		17	13
	SAN FRANCISCO				8	5
NEW YORK		11,332	13,807		20	13
	WASHINGTON			1	19	5
BOSTON		10,815	12,972	1	17	7
	NEW YORK				20	13
LOS ANGELES		7 950	8,940		17	13
	LAS VEGAS				3	2
CHICAGO		4,547	6,309	1	11	6
	MINNEAPOLIS				6	6
SAN FRANCISCO		4,539	6,313		8	5
	RENO				2	2
CHICAGO		4,235	5,436	1	11	6
	DETROIT			1	18	8
NEW YORK		3,948	4,861		20	13
	PITTSBURGH				9	4
NEW YORK		3,826	5,023		20	13
	CLEVELAND			1	7	4
SAN DIEGO		3,804	5,201	1	4	3
	SAN FRANCISCO				8	5

Table 10. Summary of Existing Airports (Continued)

CITY PAIR		DAILY AIR PASSENGERS		NUMBER OF CBD AIRPORTS	NUMBER OF URBAN AIRPORTS	
		1980	1990		TOTAL	≥3,000 FT
DALLAS/FT WORTH		3,646	5,446		31	15
	HOUSTON				10	6
LOS ANGELES		3,584	3,969		17	13
	SAN DIEGO			1	4	3
BOSTON		3,479	4,782	1	17	7
	WASHINGTON			1	19	5
CHICAGO		3,457	4,751	1	11	6
	ST LOUIS				9	4
LOS ANGELES		3,397	4,805		17	13
	PHOENIX				7	2
NEW YORK		3,365	4,445		20	13
	BUFFALO				7	3
NEW YORK		3,219	3,920		20	13
	HARTFORD				7	4
LOS ANGELES		2,998	3,668		17	13
	SACRAMENTO				6	3
NEW YORK		2,940	3,687		20	13
	ROCHESTER				1	1

Table 10. Summary of Existing Airports (Continued)

CITY PAIR		DAILY AIR PASSENGERS		NUMBER OF CBD AIRPORTS	NUMBER OF URBAN AIRPORTS	
		1980	1990		TOTAL	≥3,000 FT
CHICAGO		2,887	3,298	1	11	6
	INDIANAPOLIS				8	6
NEW YORK		2,843	3,732		20	13
	DETROIT				18	8
NEW YORK		2,812	3,301	1	20	13
	PHILADELPHIA				36	8
NEW YORK		2,713	4,476		20	13
	PROVIDENCE				3	2
SACRAMENTO		2,678	3,127		6	3
	SAN FRANCISCO				8	5
MIAMI		2,664	4,076		5	5
	TAMPA				10	11
BOSTON		2,616	3,524	1	17	7
	PHILADELPHIA				36	8
PHILADELPHIA		2,550	3,179		36	8
	PITTSBURGH				9	4
CHICAGO		2,496	3,370	1	11	6
	CLEVELAND			1	7	4

Table 10. Summary of Existing Airports (Continued)

CITY PAIR		DAILY AIR PASSENGERS		NUMBER OF CBD AIRPORTS	NUMBER OF URBAN AIRPORTS	
		1980	1990		TOTAL	≥3,000 FT
NEW YORK SYRACUSE		2,432	3,525		20 6	13 2
HOUSTON NEW ORLEANS		2,364	3,787		11 2	6 2
CHICAGO KANSAS CITY		2,093	3,196	1	11 9	6 3
SAN FRANCISCO FRESNO		2,090	2,727		8 4	5 3
CHICAGO PITTSBURGH		2,078	2,685	1	11 9	6 4
SAN FRANCISCO LAS VEGAS		2,068	2,810		8 3	5 2
SEATTLE PORTLAND		2,027	2,955		12 7	5 2
ATLANTA JACKSONVILLE		1,950	3,493		7 3	3 3
DALLAS/FT WORTH SAN ANTONIO		1,924	3,182		31 7	15 3
LOS ANGELES SALINAS/MONTEREY		1,854	2,727		17 5	13 2
DENVER SALT LAKE CITY		1,819	2,805		15 3	10 3

Table 10. Summary of Existing Airports (Continued)

CITY PAIR		DAILY AIR PASSENGERS		NUMBER OF CBD AIRPORTS	NUMBER OF URBAN AIRPORTS	
		1980	1990		TOTAL	≥3,000 FT
DETROIT	WASHINGTON	1,809	2,621	1 1	18 19	8 5
DALLAS/FT WORTH	NEW ORLEANS	1,741	3,387		31 2	15 2
BALTIMORE	NEW YORK	1,739	2,332		5 20	2 13
NEW YORK	COLUMBUS	1,692	2,362		20 5	13 8
NEW YORK	ALBANY	1,691	2,296		20 5	13 1
SEATTLE	SPOKANE	1,685	2,552		12 4	5 2
CHICAGO	COLUMBUS	1,648	2,211	1	11 15	6 8
WASHINGTON	PHILADELPHIA	1,642	2,170	1	19 36	5 8
WASHINGTON	CLEVELAND	1,605	2,245	1 1	19 7	5 4
ATLANTA	TAMPA	1,601	2,851		7 10	3 11

Table 10. Summary of Existing Airports (Continued)

CITY PAIR		DAILY AIR PASSENGERS		NUMBER OF CBD AIRPORTS	NUMBER OF URBAN AIRPORTS	
		1980	1990		TOTAL	≥3,000 FT
DALLAS/FT WORTH		1,589	2,742		31	15
	AUSTIN				3	2
HONOLULU		1,549	2,136		2	1
	LIHUE				4	1
JACKSONVILLE		1,512	2,944		3	3
	MIAMI				5	5
DETROIT		1,466	2,140	1	18	8
	PHILADELPHIA				36	8
KANSAS CITY		1,453	2,241		9	3
	ST LOUIS				9	4
HONOLULU		1,426	1,943		2	1
	HILO				3	1
NEW YORK		1,409	2,484		20	13
	RALEIGH/DURHAM				5	4
WASHINGTON		1,405	1,834	1	19	5
	NORFOLK				3	3
LOS ANGELES		1,402	1,972		17	13
	TUSCON			1	4	4
CHICAGO		1,393	1,857	1	11	6
	CINCINNATI				4	4

Table 10. Summary of Existing Airports (Continued)

CITY PAIR		DAILY AIR PASSENGERS		NUMBER OF CBD AIRPORTS	NUMBER OF URBAN AIRPORTS	
		1980	1990		TOTAL	≥3,000 FT
DETROIT		1,393	1,705	1	18	8
	PITTSBURGH				9	4
DALLAS/FT WORTH		1,376	2,163		31	15
	OKLAHOMA CITY			1	6	5
CHICAGO		1,359	2,021	1	11	6
	LOUISVILLE				4	2
ATLANTA		1,307	2,279		7	3
	MEMPHIS				4	2
HONOLULU		1,296	1,819		2	1
	KAHULUI				1	1
DALLAS/FT WORTH		1,282	2,339		31	15
	KANSAS CITY				9	3
PHILADELPHIA		1,258	1,846		36	8
	CLEVELAND			1	7	4
WASHINGTON		1,229	2,002	1	19	5
	HARTFORD				7	4
WASHINGTON		1,211	1,634	1	19	5
	PITTSBURGH				9	4
LOS ANGELES		1,200	1,557		17	13
	FRESNO				4	3

Table 10. Summary of Existing Airports (Continued)

CITY PAIR	DAILY AIR PASSENGERS		NUMBER OF CBD AIRPORTS	NUMBER OF URBAN AIRPORTS	
	1980	1990		TOTAL	≥3,000 FT
NEW YORK GREENSBORO	1,178	1,961		20 10	13 2
CHICAGO MEMPHIS	1,175	1,872	1	11 4	6 2
MILWAUKEE MINNEAPOLIS	1,173	1,835		8 6	3 6
NEW YORK NORFOLK	1,142	1,638		20 3	13 3
DETROIT ST LOUIS	1,091	1,669	1	18 9	8 4
DETROIT MILWAUKEE	1,088	1,552	1	18 8	8 3
CHICAGO OMAHA	1,062	1,752	1	11 6	6 3
CHICAGO DES MOINES	1,009	1,514	1	11 3	6 1
CHICAGO DAYTON	995	1,313	1	11 6	6 5
NEW YORK RICHMOND	975	1,519		20 5	13 3

Table 10. Summary of Existing Airports (Continued)

CITY PAIR	DAILY AIR PASSENGERS		NUMBER OF CBD AIRPORTS	NUMBER OF URBAN AIRPORTS	
	1980	1990		TOTAL	≥3,000 FT
BALTIMORE BOSTON	953	1,399	 1	5 17	2 7
DETROIT INDIANAPOLIS	869	1,053	1	18 8	8 6
PHILADELPHIA BUFFALO	779	1,228		36 7	8 3
CHICAGO BUFFALO	759	1,223	1	11 7	6 3
DETROIT CLEVELAND	733	949	1 1	18 7	8 4
BOSTON PITTSBURGH	722	1,003	1	17 9	7 4
HONOLULU KAILUA	683	1,032		2 1	1 1
BOSTON BUFFALO	635	1,010	1	17 7	7 3
GRAND TOTAL	212,436	287,530			
UNDUPLICATED GRAND TOTAL			8	472	269

C. 1980 STOLPORT FACILITY NEEDS

Consideration must be given to the STOLport facility requirements for terminal area for passenger processing, auto parking area, aircraft loading gates and aircraft maintenance if the objectives of improved passenger service and convenience are to be realized. These facilities are a function of both the peak hourly passengers and aircraft operations at each of the STOLports. The 1980 projected annual passenger demand is converted to annual STOL aircraft operations using 150-passenger STOL aircraft operating at 55 percent load factor and 2500 hours per year utilization. The capability of the STOLports to handle the projected operations was determined by checking the 1980 FAA PANCAP* for the selected airports.[16] In general, the selected reliever ports have more than adequate capacity to accept the projected operations; however, in the two cases of Chicago and New York it was necessary to add one additional STOL reliever port to the city's airport system. The additional airports are over and above the minimum number of airports previously identified as required for public convenience.

The passenger facilities for STOL operations are described as special facilities separated from the other scheduled airline operations so as to eliminate passenger processing and auto parking delays. The elimination of passenger delays required the definition of special aircraft processing capability also. These facilities were sized on the basis of the 1980 forecasts for peak hourly passengers and STOL aircraft operations for each of the selected reliever ports. The 1980 facility needs for the Chicago-Detroit city pair are shown as example typical requirements in Table 11, along with the STOL system requirements for the 61 cities. The table lists the required number of aircraft loading gates, the passenger terminal area in acres, the STOL auto parking area in acres, and the number of STOL aircraft maintenance facilities. The land is available at the selected airports for the facilities but the facilities will require new construction.

*Practical Annual Capacity

Table 11. STOLport Facility Needs

		Gates	Terminal Area (Acres)	Parking Area (Acres)	Maint. Facilities
Typical Requirements	Chicago - Midway	4	3.2	24	1
	- Meigs	3	2.2	17	-
	Detroit - City	4	3.9	24	0
System Requirements	61 Cities Total	135	110	680	12
	Existing or Planned	--	--	--	--
	New	135	110	680	12

D. POTENTIAL STOL SYSTEM BENEFITS

The STOL system was defined primarily on the basis of improved passenger service and convenience; however, there are other potential benefits that may be derived from the introduction of the system. These potential benefits are noise reduction at existing reliever ports, introduction of service at new reliever ports without significant noise increase, the reduction of air congestion at major CTOLports and the reduction of ground congestion at major CTOLports. The potential benefit of STOL aircraft operations would result from the use of quiet engines and of increased angle of approach and departure profiles. The potential reduction in air and ground congestion results when STOL traffic is diverted to reliever airports.

1. NOISE RELIEF

The noise impact at an airport is a function of the noise levels of the aircraft types, the number of operations of the different types, the takeoff and approach flight profiles and speeds, the number of daily operations of each type of aircraft and the time of day at which these operations occur. The noise exposure forecast (NEF) approach, described in Reference 20,

takes all of these factors into account, and can be used to define a contour, or footprint, bounded by a given NEF level.

The airport operations mixes assumed in the noise evaluation were based on the FAA predictions[16] of the 1980 capacities for the four different example categories of airports defined. The airport categories are based on FAA airport planning criteria that include mixes of aircraft and numbers of operations with the resulting definitions shown in Table 12. Each of the selected STOLports has been assigned to one of these four typical airport operational categories so that a separate noise analysis would not be required for every airport. The definition of operating mix was then modified to include STOL aircraft as a replacement for the two- and three-engine jet aircraft (shown as a shaded column in Table 12).

Table 12. Airport Operations Assumed for Noise Evaluation at 1980 Airports

	FAA CHARACTERIZATION							TYPICAL DAY & NIGHT OPERATIONS	
		AIRCRAFT MIX, PERCENT							
OPERATIONAL CATEGORY	AIRPORT CATEGORY	4 ENG JET	2 & 3 ENG JET	EXEC JET & 2 ENG PISTON	1 OR 2 ENG LIGHT PISTON	MAXIMUM PRACTICAL ANNUAL OPERATIONS (SINGLE RUNWAY)	DAILY OPERATIONS	DAY (0700-2200)	NIGHT (2200-0700)
GENERAL AVIATION	1	0	0	10	90	215,000	584	584	0
RELIEVER	2	0	30	30	40	195,000	531	531	0
MAJOR DOMESTIC	3	20	40	20	20	180,000	493	444	49
MAJOR INTER-NATIONAL	4	60	20	20	0	170,000	466	420	46

OPERATIONS REMOVED OR REPLACED WITH STOL AIRCRAFT

The aircraft noise technology considerations and target noise levels were discussed in the aircraft technology section. A summary of the anticipated trend in typical aircraft noise is illustrated in Figure 20. The noise level from the 1960 Boeing 707 aircraft represents the noise levels generated with little jet engine noise suppression. The McDonnell Douglas DC-10 design of 1970 halves the 707 noise levels while doubling the aircraft capacity and reducing the required runway length. The DC-10 typifies the improvement available with today's technology. The aircraft noise levels achievable in 1980 and 1990 are estimated based on extensions of today's technology and represent halving the aircraft noise every decade. The 1980 aircraft estimated noise levels and the aircraft and operations mixes of Table 12 were used to generate NEF contours for the four categories of airports with and without STOL aircraft. Single runway airports were used since they are representative of many reliever airports, and multiple runway configurations are unique to each airport. The resulting NEF contours permit a comparison of the effect of STOL introduction at the different airports.

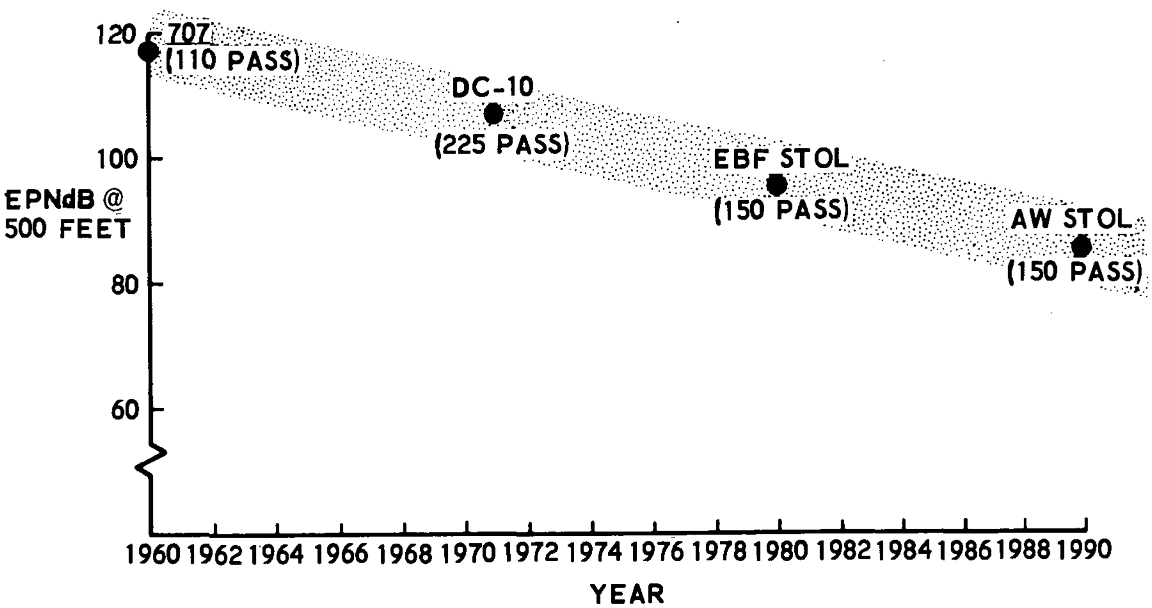


Figure 20. Aircraft Noise Level Goals

The NEF level has been related to land utilization[20] as shown in Figure 21. While such a definition is always subjective due to individual differences in noise acceptance, the NEF criterion does provide a relative indicator of noise impact effects. The 30 NEF value represents a nominal maximum acceptable residential level and was used for comparison of noise impact.

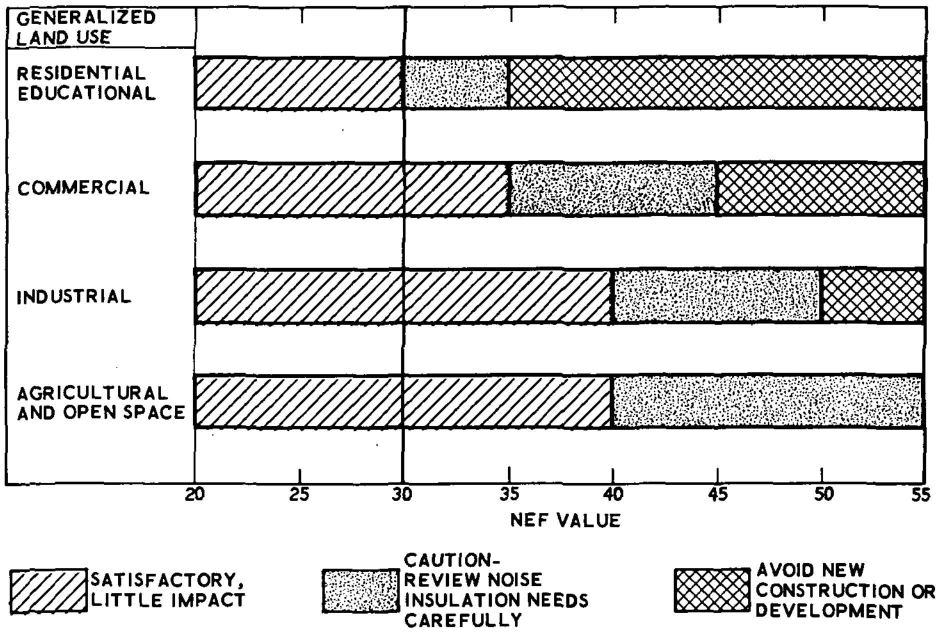


Figure 21. Land Use Related to Noise Exposure Forecast Values

The amount of land area in acres inside the 30 NEF contours for the four operational categories of airports for 1970, 1980 and 1990 are shown in Figure 22. The major effect of interest here is the reduced 30 NEF contour of the reliever airport where all two- and three-engine jet activity is

converted from CTOL to quiet STOL with the result that the 30 NEF contour for the reliever port is approximately the same as for the general aviation case. These data also show that the effectiveness of STOL in reducing noise becomes much less noticeable as it is combined with current jets at major CTOL airports. Significant noise reduction improvement for these airports will be dependent on development and introduction of a quiet long and medium haul CTOL. However, a portion of the CTOL noise could be reduced by utilization of approach and climb-out flight paths at steeper angles.

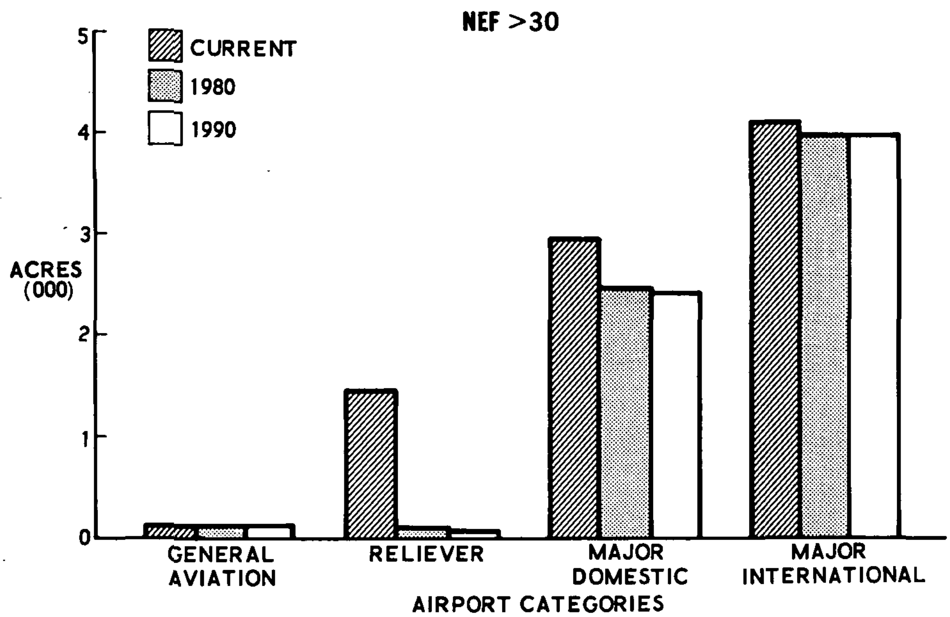


Figure 22. Individual Airport Noise Impacted Areas

The potential community noise relief for the complete 1980 STOL system is summarized in Table 13. The total impacted land area for the 30 NEF contour could drop from 151,000 acres in 1970 to 83,000 acres in 1980 for a net reduction of 68,000 acres. At the 42 reliever airports the new quiet STOL system can reduce the impacted area by 90 percent. This community noise relief should allow the new short haul air system to obtain public acceptance and support.

Table 13. Community Noise Relief

AIRPORT CATEGORY	1980 SHORT HAUL AIRPORTS		TOTAL IMPACTED AREA (ACRES)		NET CHANGE (ACRES)
	STOL PORTS	CTOL PORTS NOT USED	1970	1980	
GENERAL AVIATION	15	—	2,000	2,000	—
RELIEVER	42	—	63,000	6,000	-57,000
MAJOR DOMESTIC	11	9	60,000	50,000	-10,000
MAJOR INTERNATIONAL	1	5	26,000	25,000	-1,000
TOTAL	69	14	151,000	83,000	-68,000

2. AIR AND GROUND CONGESTION RELIEF

Air and ground congestion have become critical problems at many major CTOL airports. While the widebody jets and scheduling have provided temporary improvement in some cases, the anticipated growth in air traffic by 1980 will significantly aggravate the problem. The distribution of the local short haul traffic to the reliever STOLports has the potential to relieve the air and ground congestion at the major CTOLports. The projected 1980 annual scheduled aircraft operations[17] at the CTOLports for the top 16 U. S. air hubs, along with the local short haul portion of these aircraft operations which could be shifted to a reliever or secondary airport is shown in Figure 23. The amount of air congestion relief afforded varies between hubs depending upon what percentage of the total operations are high density short haul. Excellent relief can be provided to most of the cities with major air congestion. The diverted short haul operations can allow for 20% or more increased growth capability for the long haul and connecting CTOL service.

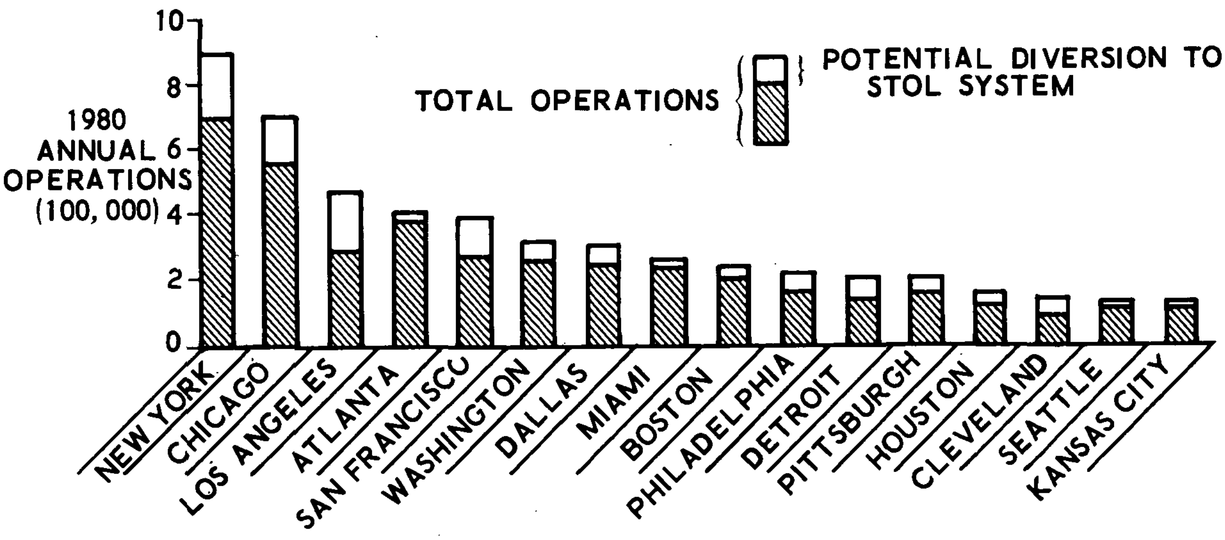


Figure 23. Air Congestion Relief

The number of peak hourly cars potentially diverted from the CTOL-ports to the reliever ports is shown in Figure 24. The number of cars diverted is a direct function of the number of local short haul peak hourly passengers diverted from the CTOLport to the reliever port. The relation between autos and passengers is based on survey data for major U. S. airports.[18] This shift of autos is significant in reducing the airport access and ground congestion problems and is equivalent to freeing two lanes of freeway traffic or three or more lanes of surface streets at the large CTOLports. This ground congestion relief could allow additional CTOL traffic growth.

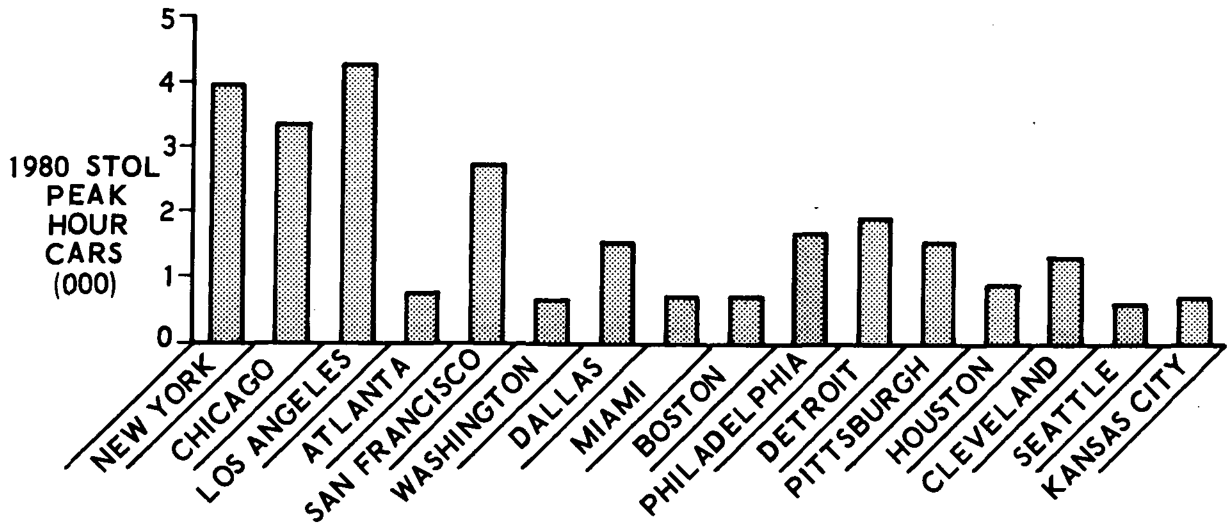


Figure 24. Ground Congestion Relief

E. AIR TRAFFIC CONTROL NEEDS

A primary operational difference between the CTOL aircraft and the STOL and VTOL propulsive lift designs is the capability for steeper approach and climb-out flight path angles. In addition, STOL and VTOL aircraft have improved maneuvering capability at low speed that may permit them to use holding areas and airport approaches different than those utilized by the CTOL operations. For either a STOL or VTOL system to achieve viability the system must not be encumbered by the inherent delays of the current CTOL air traffic control system. This may necessitate separate and direct routes taking advantage of area navigation techniques. Moreover, the low-speed STOL characteristics will require new STOL terminal areas with navigation and landing aids capable of handling the steeper flight path angles.

A review of the FAA development plan for the upgraded third generation air traffic control (ATC) system[19] indicated that it would provide the necessary support to the hypothesized STOL system for the 1980 time period. This plan is briefly illustrated in Figure 25. In the implementation of this plan the time period from 1970 to 1975 is used to develop new subsystems, 1976 to 1978 to field test with initial deployment of the new system beginning in 1978 with the system 50% complete by 1980 and completely installed by 1984. The ATC system requirements are essentially the same for CTOL and V/STOL so the system will have the inherent capability of handling the STOL and VTOL aircraft even though the detail plan is yet to be defined. The specific requirements for STOL and VTOL will be established sufficiently prior to operational requirements to permit necessary modifications to equipment or procedures. The effects of steeper flight path angles and separate air space will have to be assessed to establish the required field locations and numbers of system components.

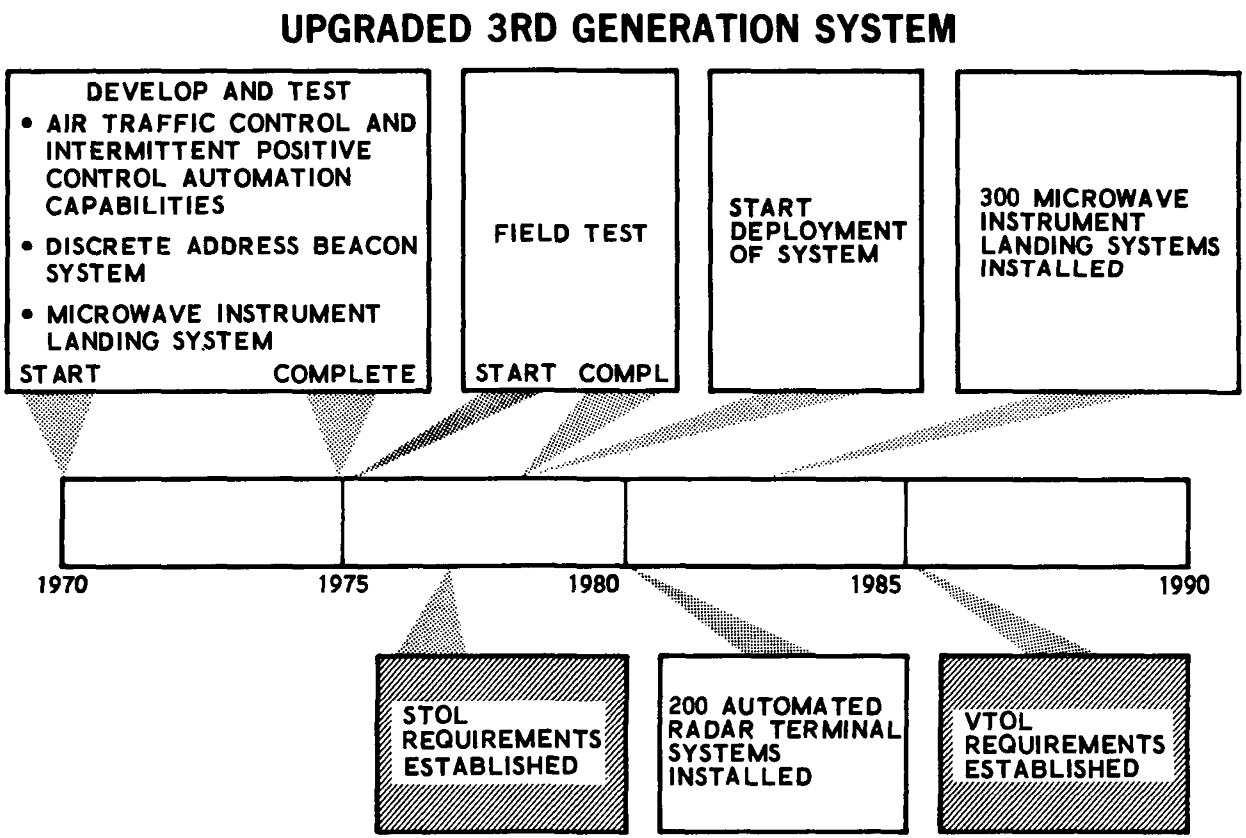


Figure 25. Air Traffic Control Development Plan

The air traffic control system includes a number of components such as the tower, microwave landing system, lighting, area surveillance radar and computer assisted approach system. Most of these are scheduled for installation as a part of the third generation ATC system. The air traffic control needs for STOLport navigation and landing systems are given in Table 14. The typical requirements for the Chicago-Detroit city pair are listed along with the total system requirements for all of the STOLports in the 61 cities. Only those equipments listed as new are additions to the currently planned or existing system.

Table 14. Air Traffic Control Needs

		NAVIGATION AND LANDING SYSTEMS				
		TOWER	MLS	APPROACH LIGHTING	AREA SURVEIL-LANCE RADAR	COMPUTER ASSISTED APPROACH SYSTEM
TYPICAL REQUIREMENTS	CHICAGO - MIDWAY	1	1	1	1	1
	- MEIGS	1	1	1		
	DETROIT - CITY	1	1	1	1	1
SYSTEM REQUIREMENTS	61 CITIES TOTAL	71	71	71	60	16
	EXISTING OR PLANNED	65	.65	—	54	16
	NEW	6	6	71	6	—

VII. IMPLEMENTATION COSTS AND FUNDING

A time-phased implementation funding analysis was developed for the 1980 STOL scenario and the 1990 VTOL scenario. The schedule and funding analysis have been developed considering the required technology, performance and development, and acquisition and introduction costs of the 1980 and 1990 systems. The major system cost elements for the 1980 STOL and 1990 VTOL systems are shown in Table 15.

Table 15. System Cost Elements

	1980	1990
• RESEARCH	• QUESTOL AIRCRAFT • QUIET ENGINE	• QUIET VTOL AIRCRAFT CONCEPTS • QUIET LIFT FAN ENGINE • COMPOSITE MATERIALS
• AIRCRAFT PRODUCTION	• STOL AIRCRAFT AND ENGINE DEVELOPMENT • PRODUCTION OF 325 STOL AIRCRAFT • SPARE PARTS	• VTOL AIRCRAFT AND LIFT FAN DEVELOPMENT • PRODUCTION OF 210 VTOL AIRCRAFT • SPARE PARTS
• PORT FACILITIES	• 69 NEW TERMINALS • 12 MAINTENANCE FACILITIES • APRONS, PARKING LOTS, GATES	• 8 ELEVATED PORTS • 9 SURFACE PORTS • 8 MAINT. FACILITIES
• NAVIGATION AND LANDING AIDS	• 69 NEW APPROACH LIGHTING SYSTEMS • 6 TOWERS AND ALL OTHER REQUIRED FACILITIES	• 17 COMPLETE NEW SYSTEMS INCLUDING CAT. IIIC LANDING CAPABILITY
• INTRODUCTION	• CREW TRAINING • PUBLICITY • GROUND SUPPORT EQUIP.	• CREW TRAINING • PUBLICITY • GROUND SUPPORT EQUIP.

The research elements for the 1980 STOL include the NASA development of experimental STOL aircraft and a quiet clean experimental engine. The 1990 VTOL research costs include NASA development of an experimental VTOL aircraft, a quiet lift fan engine and composite materials. The pacing item for the 1980 STOL is the quiet engine development program. Any delay in this program would delay the availability of STOL for 1980 introduction. The development of a viable quiet VTOL system requires a high level of composite materials which will dictate continuing study to meet the schedule date.

The system cost element listing in Table 15 is generally chronological, but there will be overlap between the time and funding for the different major elements. The research part of the program will be primarily a NASA responsibility. The development and production will be primarily industry responsibility based on the NASA results.

The aircraft development costs are associated with the level of technology required to develop the airframe and engine. These development costs are in addition to the NASA technology development associated with the quiet clean experimental engine and the QUESTOL research aircraft. Airline acquisition cost is the flyaway cost of the aircraft which include amortization of development costs based on the U. S. domestic production base of 325 STOL aircraft and 210 VTOL aircraft.

STOLport development dollars are for improving existing air carrier and general aviation airports while VTOLports are for land acquisition and construction of appropriate VTOLports.

Air traffic control facilities and equipment for the 1980 STOL system are limited to a few additional control towers, microwave ILS, and approach lighting systems, For the 1990 VTOL system, additional terminal air control, communications, data acquisition, and navigation landing aids are assumed. The introduction costs are one-time expenditures associated with crew training, publicity, and ground support equipment to introduce the new systems.

The cost summary for the 1980 STOL system, 1990 VTOL system and combined 1980 STOL and 1990 VTOL systems is illustrated in Figure 26. The aircraft cost, including development and spares, represents eighty percent of the system cost. The terminal and maintenance facilities are the second largest dollar expenditure followed in turn by the aircraft and engine research, the ground support equipment, the introduction and the navigation and landing aids costs. VTOLport development costs are significantly higher than STOLports because of the need for new land acquisition and new facility construction. Similarly, VTOLports require new air traffic control facilities instead of utilizing existing facilities as for the STOL system; however, because of the limited number of 1990 CBD VTOLports required the total VTOLport expenditures are about equal to the 1980 STOLport costs.

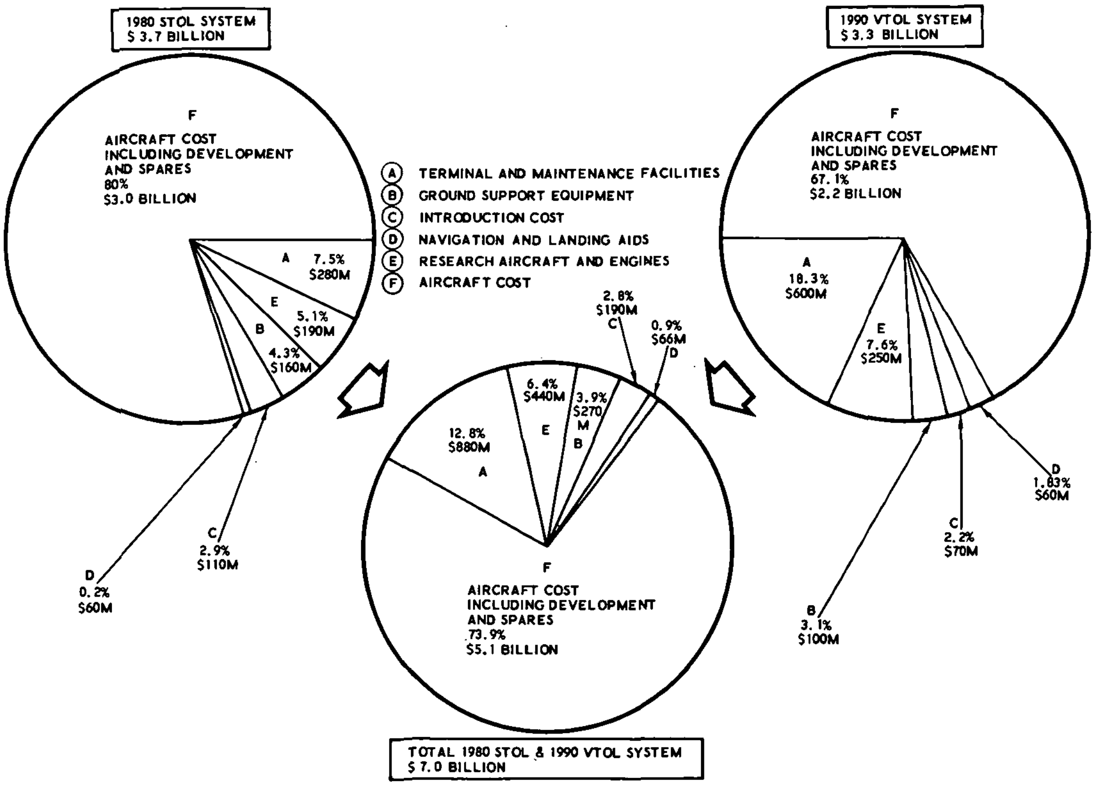


Figure 26. Cost Summary, 1980 STOL and 1990 VTOL Systems

A time-phased cumulative implementation cost summary is shown in Figure 27 for both the 1980 STOL and 1990 VTOL systems. Implementation expenses for both systems during the initial two to three year period are solely associated with development and research of the aircraft and engine and the definition of the short haul market needs. The principal expenditures for the 1975 to 1980 time period are associated with the STOL aircraft and engine production while the major items for the 1980 to 1985 period are attributable to the airlines taking delivery of the aircraft. Similarly, from 1985 to 1990 the principal cost item is the VTOL aircraft and lift fan engine production and from 1990 to 1995 the airline delivery is paramount.

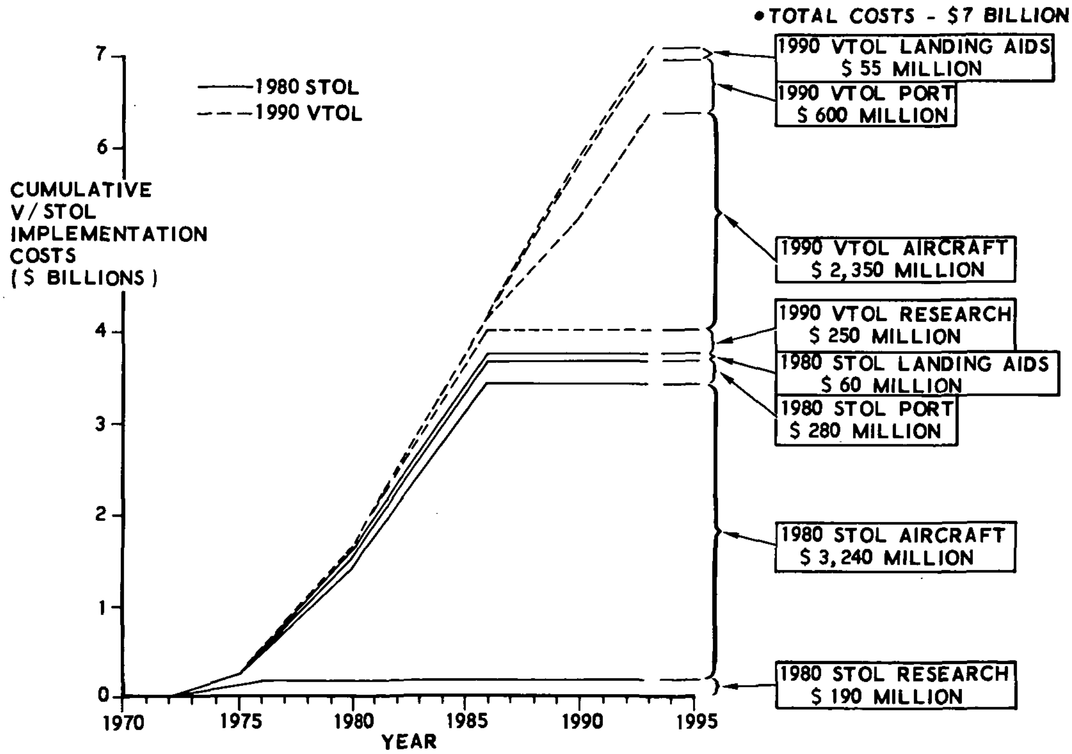


Figure 27. 1980 STOL and 1990 VTOL System Cumulative Cost

The various V/STOL system funding participants are listed in Table 16 giving the participants, the funding sources and the funding requirements. The participants consist of both public and private parties who are normally involved in financing new air transportation systems. The public parties are airport authorities and various agencies of the federal government, while the private parties are lending institutions, airlines and manufacturers. Private industry funds come from either operating revenues or the lending institutions (banks, insurance companies and annuity funds). Airport authorities funds may come from operating revenue, revenue bonds or federal matching fund programs. Federal agencies (NASA and the FAA) are funded by Congress or through the Airport Development Aid Program (ADAP) trust fund.

Table 16. V/STOL Funding Participants

PARTICIPANTS	SOURCE	REQUIREMENT
• LENDING INSTITUTIONS	• BANKS • INSURANCE COMPANIES • ANNUITY FUNDS	• AIRLINES • AIRPORT AUTHORITIES • MANUFACTURING INDUSTRY
• AIRLINES	• OPERATING REVENUE • LENDING INSTITUTIONS	• AIRCRAFT PURCHASES • INTRODUCTION COSTS
• FEDERAL GOVERNMENT		
NASA	• CONGRESSIONAL FUNDING	• RESEARCH
FAA	• AIRPORT DEVELOPMENT AID PROGRAM PLAN (ADAP) • CONGRESSIONAL FUNDING	• V/STOL AIR TRAFFIC CONTROL, NAVIGATION & LANDING AIDS
• MANUFACTURING INDUSTRY	• OPERATING REVENUE • LENDING INSTITUTIONS	• V/STOL AIRCRAFT & QUIET ENGINE DEVELOPMENT • PRODUCTION
• AIRPORT AUTHORITIES	• OPERATING REVENUE • LENDING INSTITUTIONS • ADAP (FAA)	• TERMINALS • MAINTENANCE FACILITIES • RAMPS & TAXIWAYS • AUTO PARKING

Sources of financial support needed for the total development of the 1980 STOL and 1990 VTOL systems are shown in Figure 28. NASA should fund the research and development costs for both the experimental quiet engines and also the STOL and VTOL research aircraft if the operational dates are to be met. Commercial banks would provide the principal funds for aircraft development, airline acquisition, and STOL and VTOL port development. Commercial banks may be expected to finance 70% of aircraft and engine development and manufacture, with the airlines financing 30% of the flyaway price plus spares, ground support equipment, and 100% of introduction costs.

For the 1980 STOL system it is assumed that airport authorities and the FAA will share airfield development costs on a 50-50 basis. Support facility costs covering passenger terminal and airport parking will be provided totally by airport authorities. Airport authorities will obtain 30% of all required implementation funds from operating revenue and 70% from sale of revenue bonds. Airlines will finance maintenance facilities, 30% from cash reserves and 70% from commercial bank loans.

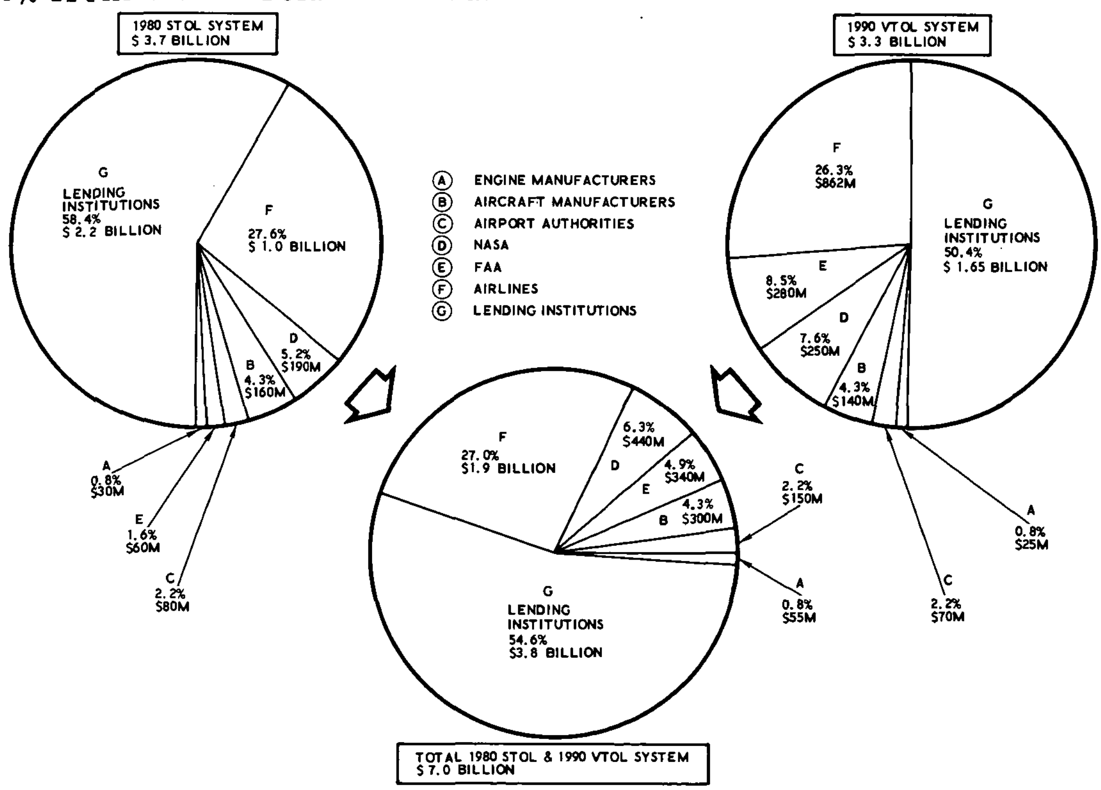


Figure 28. Funding Summary, 1980 STOL and 1990 VTOL Systems

For the 1990 VTOL system it has been assumed that the FAA will share 50% of land acquisition and construction costs, including those related to the terminal and airport parking. It is recognized that current FAA funding criteria excludes the costs of these facilities; however, since these facilities are integral to the VTOLport a needed change in funding criteria for VTOLports has been assumed. In addition, this funding may be essential if airport authorities are to be able to finance their share of VTOLport development. All air traffic control facilities and equipment necessary at each STOL and VTOL port are assumed to be provided by the FAA.

The total cost of a V/STOL system to satisfy the short haul needs of the nation to the year 1995 is about $7 billion. The federal government's share is approximately 10% of this and is entirely recoverable through airline passenger ticket tax. Private funding for the other 90% of the costs is secured with a profit through the promising economics of the new system.

VIII. IMPLEMENTATION ACTION

An airport and its accompanying operations can radically change the environment of a large contiguous territory and may significantly influence property and persons only remotely connected to it geographically. As a consequence, vigorous and serious debates frequently result over whether an airport is needed, how it is to be developed, the kind of service to be provided, how it is to operate, the nature and extent of its environmental and economic influence, and the extent of compensation to be awarded to those persons claiming losses from the introduction of the airport and its operations into the community. In response to such issues, laws and regulations have emanated at the local, regional, state and national level to help bring about orderly and effective development of air transportation. These laws and regulations establish the roles of the various government agencies and will have an influence on V/STOL airport and aircraft design objectives and constraints.

In the following sections, the roles and responsibilities of the key organizations will be discussed in terms of their impact on aircraft development, airports, airport access, air traffic control and landing aids, and airline operations.

A. PRINCIPAL ROLES AND RESPONSIBILITIES

The organizations having defined responsibilities toward air transportation are both numerous and varied. This section is focused upon those organizations considered to be of special importance to air transportation, in general, and V/STOL applications, in particular. Government agencies at all levels interrelate with airlines and airline operations. NASA, the FAA and the CAB bear major federal responsibilities for aircraft development, airports, airlines, and airways; however, the responsibilities for airport access,

frequently a limiting factor in their effectiveness, falls almost entirely outside their purview. Other agencies at the federal level do play critical roles. These include the Office of the Secretary of Transportation, the Urban Mass Transportation Agency, and the Federal Highway Administration. Important roles and responsibilities are also carried out by government agencies at the state, regional and local levels. At the state level, the principal organization is the Department of Aeronautics. At the regional level, the discussions will be limited to those regional transportation or aviation organizations whose specific purpose relates to air transportation. At the local level, the discussion will center upon organizations such as the airport authority, the urban planning agencies, and agencies concerned with surface access to the airport. Figure 29, "Principal Interactions of Responsible Parties," identifies the responsibilities that will be discussed in more detail in the subsequent paragraphs.

	FEDERAL					STATE	LOCAL
	FAA	CAB	NASA	FHWA	UMTA		
AIRCRAFT	✓	✓	✓				
AIRPORTS	✓	✓				✓	✓
AIRLINES	✓	✓				✓	
AIRWAYS	✓						
AIRPORT ACCESS	✓			✓	✓	✓	✓

Figure 29. Principal Interactions of Responsible Parties

1. FEDERAL GOVERNMENT

a. Federal Aviation Administration

Aircraft and Related Equipment Manufacturers. The FAA roles and responsibilities include involvement in aircraft development, the establishment of certification standards for V/STOL aircraft, and type and prototype certification. The interaction of this FAA role with NASA and related equipment manufacturers will be of primary importance in establishing the characteristics of V/STOL aircraft to be fashioned for the airline industry.

Airports. The Administrator of the FAA directs programs to identify the development needs of public airports and provides grants of funds to assist public agencies in airport systems planning, airport master planning and public airport development.

Approval of a project under the Airport and Airways Development Act is conditional upon its being consistent with existing planning agency projects for development of the area where the airport is to be located. Projects are not to be authorized which will have an adverse effect upon the environment, unless there is no feasible alternative. No airport development project is to be approved unless the public agencies sponsoring the project certify that the public has been given the opportunity for a hearing. The governor of the state in which the project is located is to certify that the project will comply with proper air and water quality standards.

Similarly, the Act precludes funding of the cost of parking facilities or construction, alteration, or repair of a hangar or of any part of an airport building unless those buildings are directly related to the safety of persons at the airport.

This study does not envision the creation of new airports for the 1980 STOL; however, new CBD airports may be required. Since only existing

airports were considered for the 1980 STOL system, airport development problems are minimized. With the Airport and Airways Development Act of 1970 providing matching funds for "airside" developments, the problems of persuading local communities to help create and accept a clean quiet STOL system in 1980 may be eased.

Airlines and Airline Operation. The FAA issues and administers air safety regulations, certifies the safety of aircraft for operations, and establishes uniform aircraft and operations safety standards. The FAA establishes the standards, gives the appropriate tests and issues licenses for airmen and maintenance personnel. This work should be completed before the planned STOL flight crew training can be initiated in 1979.

Airways and Air Traffic Control. The FAA bears almost sole responsibility for the Federal Airways System which it plans, finances, owns, and operates.

FAA's research and development programs include work on a semi-automatic ATC system, microwave instrument landing system, large screen displays for ATC, and improvements in its Airport Surveillance Radar. Currently planned FAA equipment and facilities have an inherent capability for handling a 1980 STOL. However, the STOL airspace (terminal and route) has not yet been defined.

Since ownership and control of the Federal Airways System is vested in the FAA, minimum delays are expected in implementing V/STOL applications as a consequence of the necessity for airspace studies or for the construction of whatever additional ATC and landing aids might be required.

b. Civil Aeronautics Board

Airports. The CAB approves particular airports to serve particular areas with air service. It authorizes routes which influence airport planning

and design. With the Interstate Commerce Commission, the CAB establishes air cargo and pickup zones. It has studied the problems of airport congestion by 1975. It forecasts the growth of scheduled domestic passenger air traffic, and conducts origin-destination surveys of airline passenger traffic.

Airlines and Airline Operations. The CAB plays the primary role in terms of its economic regulation of airlines. Under the terms of the Federal Aviation Act of 1958, particularly Title X of the Act, the CAB's powers include: licensing or granting of operating authority; regulation of airline rates; enforcement of laws, regulations and procedures; the regulation of relationships among air carriers and between air carriers, common carriers, and other aeronautical firms.

The speeding of government decisions in the certification of a market and the CAB's route authorization can accelerate V/STOL implementation. This would provide the necessary assurance to the manufacturers and operators of an available market. Communities concerned with planning for airport developments would then be in a position of having firm data on proposed routes and service to be provided their community. However, the CAB is required to protect the interests of a variety of parties and in order to do so it must generally follow a set of time-consuming procedures. Figure 30, "Typical Schedules of CAB Actions," shows typical times required for three different decisions. While the current law does not permit basic changes in the procedures, significant speedups could occur in the scheduling time requirements if the judge's and the board's decisions could be accelerated.

The CAB also has the authority to regulate air carrier rates. A comparison of the fares currently allowed by the CAB for short haul routes and those allowed by the State of California for the intrastate carriers (Section V, Figure 15) limited to high density short haul markets shows that the current CAB regulated rates are about twice that set by the California

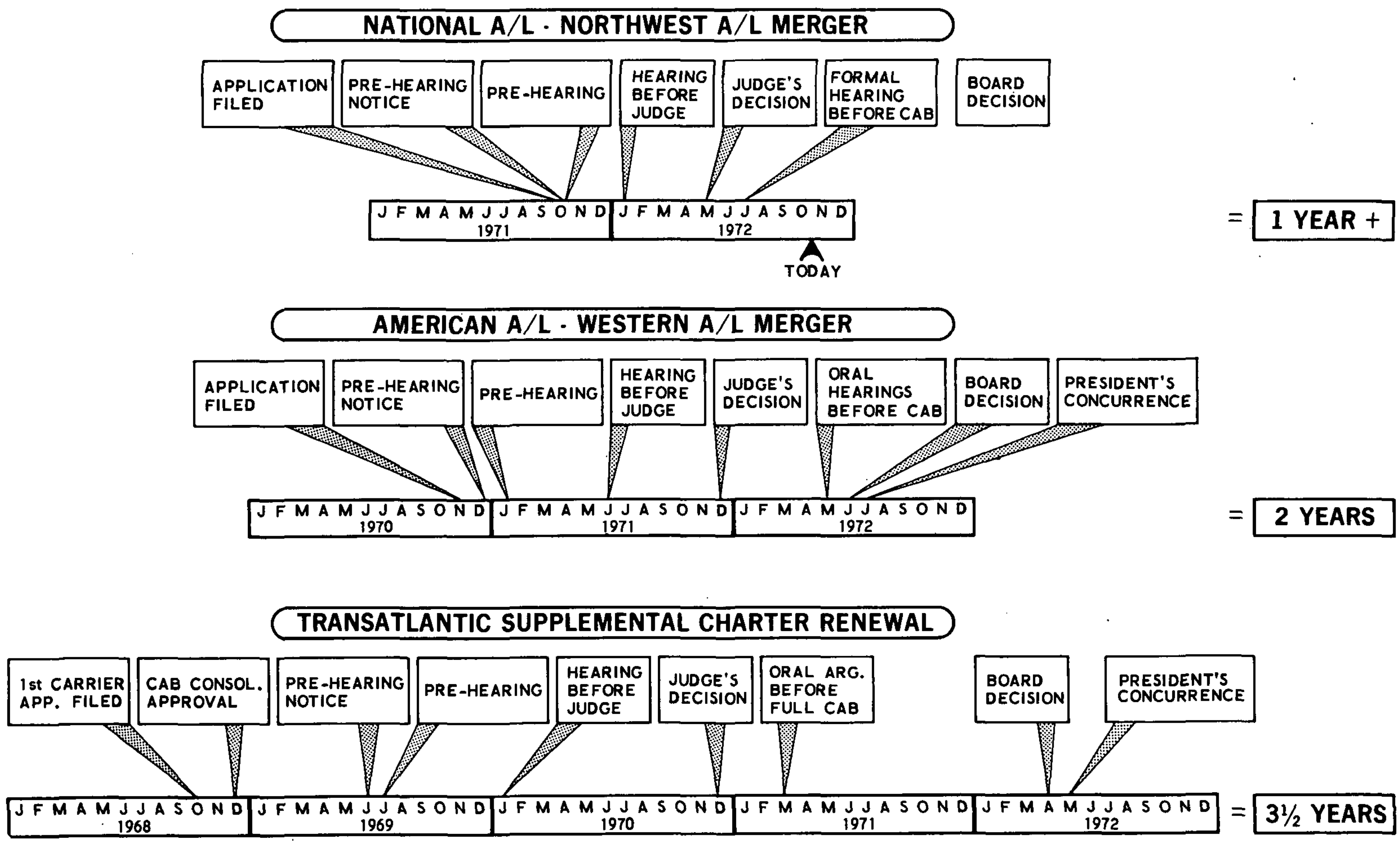


Figure 30. Typical Schedules of CAB Actions

Public Utilities Commission for intrastate carriers to operate profitably in the high density short haul market.

These fare level comparisons emphasize the need for consideration of a new and separate type of air carrier to serve this market with a new aircraft concept and an austere service catering specifically to the needs of the short haul traveler.

c. <u>National Aeronautics and Space Administration</u>

NASA's roles and responsibilities for V/STOL aircraft research and development devolve from the National Aeronautics and Space Act of 1958, as amended. One of the assigned statutory functions of NASA is to conduct research for the solution of the problems of flight and the development, construction, test, and operation of aeronautical vehicles. Its relationships with the aeronautical industry are extensive since the Act calls for the widest practicable and appropriate dissemination of information concerning NASA's activities and their results. While planning, coordination, and control of NASA's programs are vested in the Office of Aeronautics and Space Technology, the field installations, such as the Ames Research Center, are responsible for execution of NASA's programs, largely through contracts with research, development and manufacturing concerns.

One such contract, under Ames Research Center's project responsibility, is the QUESTOL program -- an acronym for quiet, experimental, short takeoff and landing aircraft. The objective of the program is to identify the required aircraft characteristics and to provide propulsive lift technology required for the development of quiet STOL transport aircraft that can help reduce community noise, ease airport congestion and improve short haul air transportation. Data from the program is then to be available to the aircraft industry for use in the development of V/STOL aircraft.

Other NASA technological research and development of relevance to potential V/STOL manufacturers includes NASA's clean, quiet engine, augmentor wing, lift fans, and externally blown flap programs. Its basic research on aerodynamic noise is of particular interest in view of the critical importance of noise suppression for the future of V/STOL applications.

Since non-technical considerations frequently constrain or modify the required aircraft research and technology development, NASA also engages in systems analysis pertinent to aircraft research and technology programs. These activities include studies of new aircraft concepts in short haul transportation systems, including noise considerations and economic analysis.

d. Other Department of Transportation Administrations

The current airport ground congestion has identified airport access as a critical item in the planning of any new air transportation system. The Department of Transportation is directly involved through two other agencies, UMTA and FHWA.

The Urban Mass Transportation Agency (UMTA) has the authority to provide grants or loans to public bodies for acquiring or improving capital equipment and facilities needed for public or privately operated mass transit systems, including airport access.

The Bureau of Public Roads of the Federal Highway Administration (FHWA) provides funds to state highway departments for constructing the interstate highway system and for building or improving primary and secondary roads and streets. The 50-50 funding of primary and secondary roads may provide some additional help with airport access.

Significant improvements in existing airport access are generally time consuming and costly. If new rapid transit systems are to be

constructed for airport access, the time delays may indeed be very great. As an example, San Francisco Bay Area Rapid Transit System and the Washington, D. C. subway require 16 to 20 years from initiation to operation. If freeways are to be developed to provide airport access, the State of California experience has shown that new freeways require about ten years. The development of surface street improvements, particularly if rights-of-way have already been acquired, provides the speediest if not the best long-term solution. Figure 31, shows lead times required for rapid transit, freeways, and improved surface streets and suggests that care must be taken in the selection of the airports to be used for the 1980 STOL system for the only new airport access that could be made available by 1980 would be improved surface streets and action must be taken by the mid-70's if a ground rapid transit system is to be integrated with VTOL airports of the 1990's.

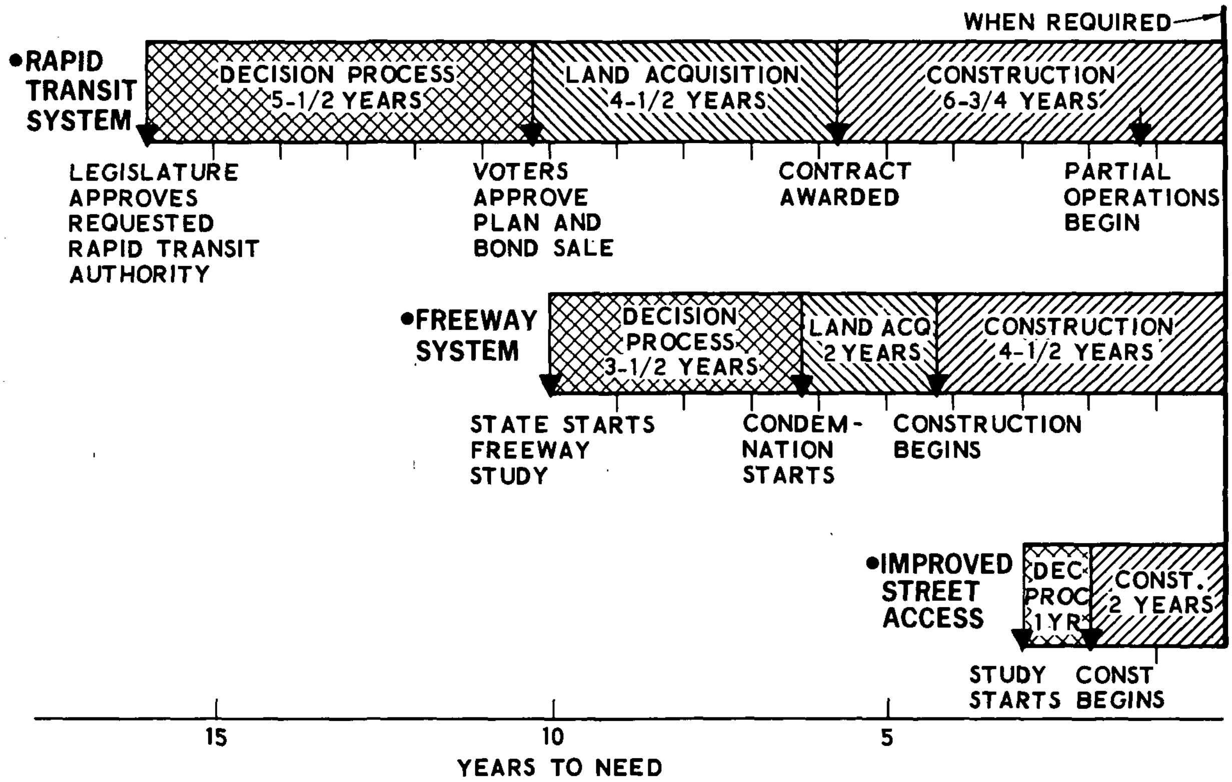


Figure 31. Representative Lead Times Required for Airport Access Development

2. STATE, REGIONAL AND LOCAL AGENCIES

a. Airports

In view of the very great impact that an airport may have upon a local community, it is not surprising that a number of agencies at the state, regional and local levels involve themselves in airport activities.

At the state level, the state may provide planning and technical aid for airport development and under some circumstances may assist the local or regional agencies with financial help concerning airport planning and development. The organization at the state level varies from state to state.

b. Airline Operations

A state may limit aircraft operations to particular areas or times and is empowered to have jurisdiction over intrastate tariffs. A regional authority may seek to specialize a particular airport for a particular kind of air service. Agencies of the local community, in particular the airport authorities, participate with the CAB in the route authority proceedings. The local community may restrict unacceptable aircraft, the hours during which airline operations will be permitted, and the uses to which the airline activities may be directed.

c. Airport Access

The state has the ability to help provide airport access improvements through the state highway department's determination of the interstate, primary and secondary road system. County and city planning commissions administer highway planning for the unincorporated and incorporated areas, respectively.

3. AIRCRAFT AND EQUIPMENT MANUFACTURERS

The dependence of aircraft and equipment manufacturers upon NASA's identification of acceptable V/STOL aircraft characteristics and the development of the technology to allow production cannot be overemphasized. The manufacturers may delay their own work on the development of a V/STOL aircraft pending the completion of such R&D activities. But the aircraft manufacturer is also likely to wait for government endorsed definitions of a market, particularly as concerns CAB route authorization and airline interests in an aircraft to service that market. The manufacturer is also dependent upon known FAA certification standards in order to have its aircraft certified.

B. TIMING OF V/STOL IMPLEMENTATION ACTIVITIES

The timing of government agency activities is critical to the future of V/STOL applications. The interdependencies are such that the action of one group is frequently dependent upon the prior completion of some other activity by another group. Figure 32, "Decision and Implementation Schedules for 1980 STOL and 1990 VTOL," was developed based on responsibilities and critical schedules previously discussed, depicting in summary fashion the time-related interdependencies. The actions required for the introduction of STOL service in 1980 and VTOL service in 1990 are noted with a box and arrow below the time line identifying the requirement and the responsible party. The time required to accomplish or implement the action is shown as a block on the appropriate time line. The key actions

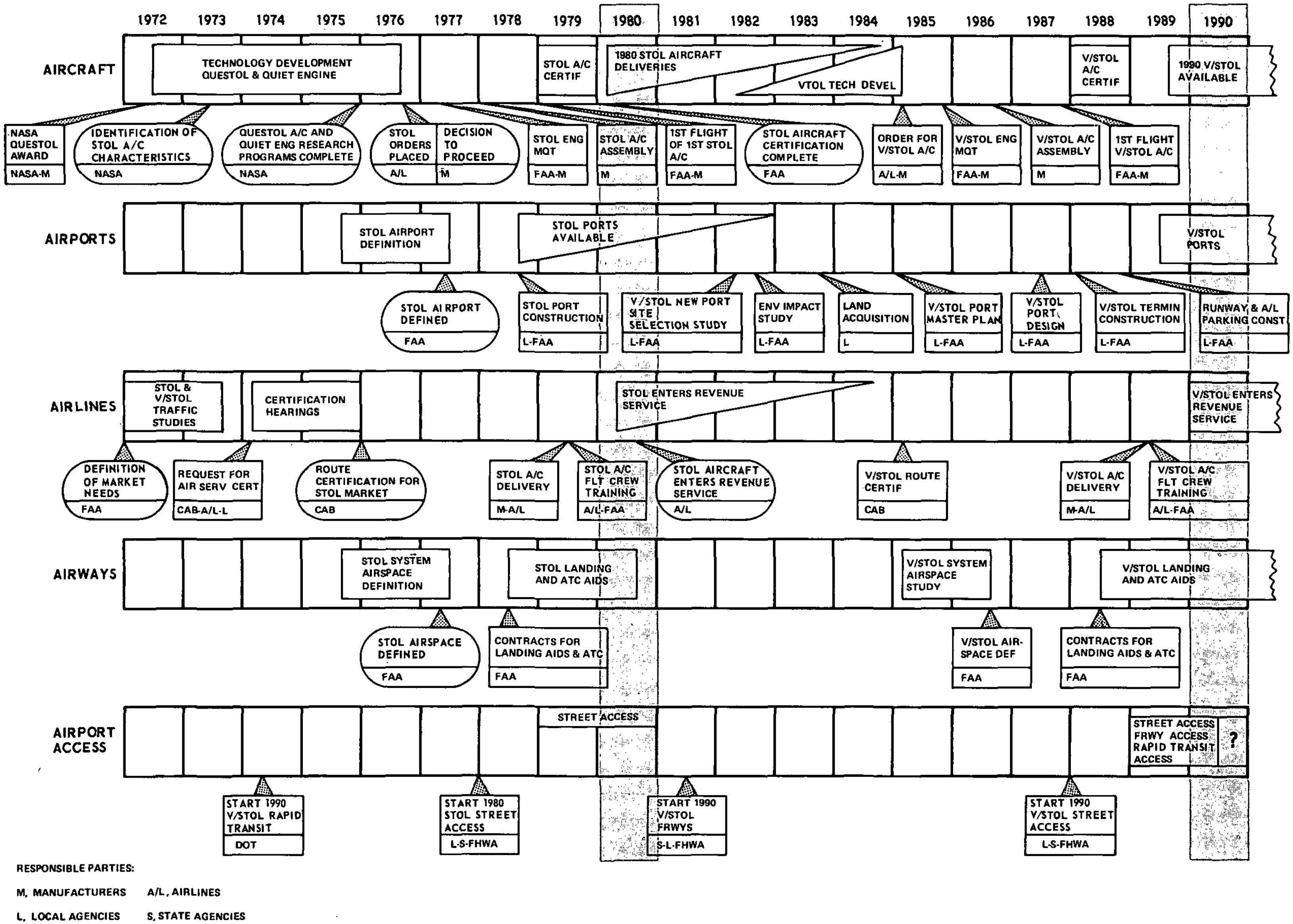


Figure 32. Decision and Implementation Schedules for 1980 STOL and 1990 VTOL

of the responsible parties for the 1980 STOL systems are shown in the rounded blocks. These critical actions are:

Key Action	Responsible Party	Time
Definition of market needs.	FAA	1973
Identify STOL aircraft characteristics.	NASA	1973
Technology development - Quiet Experimental STOL Aircraft (QUESTOL) and Quiet STOL Clean Experimental Engine (QSCEE).	NASA	1972-1975
Route certification for STOL system.	CAB	1974-1975
Place orders for STOL aircraft.	Airlines	1976
Decision to proceed with production.	Manufacturers	1976
STOL airport and airspace definition.	FAA	1975-1977
STOL aircraft enters revenue service.	Airlines	1980

The time requirements for the decisions and implementation acts are subject to considerable variations. In some instances, the time requirements are established by law, as in the stipulation that a certain number of days will elapse between notice of a CAB hearing and the hearing itself. In other cases, the time requirements cannot be defined with any precision because of uncertainties associated with technical developments. Caution in making a decision in order to safeguard all interested parties will also affect decision times.

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